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ERRATUM.

On page 111 of the preceding number, (*W.I.B.* Vol. II. No. 2) line 30 from the top, for £50 read £30.

WEST INDIAN BULLETIN

VOL. 2.] [No. 1.

AGRICULTURAL CONFERENCE, 1901.

REPORT OF PROCEEDINGS.

THE THIRD WEST INDIAN AGRICULTURAL CONFERENCE was opened on January 5, in the Hall of the House of Assembly, Barbados, under the presidency of Dr. MORRIS, C.M.G., Imperial Commissioner of Agriculture for the West Indies. There were forty-four Representatives present, representing the Botanical, Chemical and Educational Departments, as well as the principal Agricultural Societies in the West Indies. His Excellency the Acting-Governor of Barbados, the Hon. RALPH WILLIAMS, C.M.G., His Lordship the BISHOP, the Hon. Sir GEORGE PILE, Kt., the members of the Legislature and the principal planters also attended the Conference.

The following is the list of the Representatives, appointed by the several West Indian Governments to attend the Conference, who were present: –

JAMAICA.

The Director of Public Gardens and Plantations (The Honourable WILLIAM FAWCETT, B.Sc., F.L.S.)

The Government Analyst and Agricultural Chemist (HERBERT H. COUSINS, Esq., M.A.)

The Superintending Inspector of Schools (The Honourable THOMAS CAPPER, B.A., B.Sc.)

The Principal of University College, Kingston (Rev. Canon SIMMS, M.A.)

The Lecturer in Agricultural Science (W. R. BUTTENSHAW, Esq., M.A., B.Sc.)

The Acting-Entomologist to the Board of Agriculture (J. E. DUERDEN, Esq., Ph.D., A.R.C.S.)

The Vice-President of the Jamaica Agricultural Society (T. H. SHARP, Esq.,)

BRITISH GUIANA.

The Government Botanist and Superintendent of Botanic Gardens (G. S. JENMAN, F... F.L.S.)

The Principal of Queen's College (J. A. POTBURY, Esq., M. A.)
The Inspector of Schools (WILLIAM BLAIR, Esq.)
The Agricultural Assistant-in-charge of Sugar-Cane Experiments (ROBERT WARD, Esq.)
Representative of the Royal Agricultural and Commercial Society of British Guiana (FREDERICK J. SCARD, Esq., F.I.C., F.C.S.)

TRINIDAD.

The Government Analyst and Professor of Chemistry (Professor P. CARMODY, F.I.C., F.C.S.)
The Superintendent of the Royal Botanic Gardens (J. H. HART, Esq., F.L.S.)
The Acting-Inspector of Schools (J. H. COLLENS, Esq.)
The Principal of Queen's Royal College (W. BURSLEM, Esq., M.A.)
The Curator of the Botanic Station, Tobago (HENRY MILLEN, Esq.)
Representative of the Trinidad Agricultural Society (L. BERT DE LAMARRE, Esq.)

WINDWARD ISLANDS.

The Curator of the Botanic Station, Grenada (W. E. BROADWAY, Esq.)
Representative of the Grenada Agricultural Society (FREDERICK HARFORD, Esq.)

The Curator of the Botanic Station, St. Vincent (HENRY POWELL, Esq.)

The Curator of the Botanic Station, St. Lucia (J. C. MOORE, Esq.)
The Agricultural Instructor, St. Lucia (GEORGE S. HUDSON, Esq.)
The Inspector of Schools, St. Lucia (F. E. BUNDY, Esq.)

LEEWARD ISLANDS.

The Government Analyst and Agricultural Chemist (The Honourable FRANCIS WATTS, F.I.C., F.C.S.) Antigua.
The Inspector of Schools for the Leeward Islands (C. M. MARTIN, Esq., B.A.) Montserrat.
Dr. H. A. ALFORD NICHOLLS, C.M.G., M.D., F.L.S., etc., Author of "Tropical Agriculture." Dominica.
The Assistant to the Government Analyst and Agricultural Chemist (C. H. G. SPRANKLING, Esq., B.Sc.,) Antigua.

The Curator of the Botanic Station, Dominica (JOSEPH JONES, Esq.)
The Agricultural Instructor, Dominica (GEORGE W. BRANCH, Esq.)
The Curator of the Botanic Station, Antigua (W. N. SANDS,

The Agricultural Superintendent of Sugar-Cane Experiments, Antigua (F. R. SHEPHERD, Esq.)
Representative of the Antigua Agricultural Society (DONALD McDONALD, Esq.)

The Agricultural Instructor, Montserrat (A. J. JORDAN, Esq.)

BARBADOS.

The Chairman of the Education Board (His Lordship the Bishop.)
The President of the Barbados Agricultural Society (The Honourable Sir GEORGE C. PILE, Kt.)
Representatives of the Barbados Agricultural Society (The Hon'ble F. J. CLARKE, and W. D. SHEPHERD, Esq.)
The Principal of Codrington College (Rev. Canon BINDLEY, M.A., B.D.)
The Head Master of Harrison College (HORACE DEIGHTON, Esq., M.A., F.R.A.S.)
The Island Professor of Chemistry in chemical charge of Sugar-Cane Experiments (Professor J. P. d'ALBUQUERQUE, M.A., F.I.C., F.C.S.)
The Agricultural Superintendent of Sugar-Cane Experiments (J. R. BOVELL, Esq., F.L.S., F.C.S.)
The Lecturer in Agricultural Science (ALBERT HOWARD, Esq., B.A., A.R.C.S., F.C.S.)
The Inspector of Schools (Rev. J. E. REECE, M.A.)

The following Officers of the Imperial Department of Agriculture for the West Indies were also present:—
The Travelling Superintendent (GEORGE WHITFIELD SMITH, Esq.), the Technical Assistant (WILLIAM GEORGE FREEMAN, Esq., B.Sc., A.R.C.S., F.L.S.), the Entomologist (HAROLD MAXWELL-LEFROY, Esq., B.A., F.E.S.), the Acting Bee-Expert (W. K. MORRISON, Esq.,) B. MASON, Esq., Miss ROBINSON and the Acting-Secretary to the Conference (ALLEYNE GRAHAM HOWELL, Esq.).

The Inspector of Schools, Grenada (J. A. HARBIN, Esq.,) the Representative of the Dominica Agricultural Society (EDWARD ASHTON AGAR, Esq.), at the last moment, were unable to attend.

Amongst those present at the opening ceremony were, His Excellency the Acting-Governor, Hon. RALPH WILLIAMS, C.M.G., and Mrs. WILLIAMS, with Lieutenant Hamilton, A.D.C., Mrs. MORRIS, Mrs. KERR, and Mrs. W. G. FREEMAN; His Excellency Major General FOORD-HILTON; His Lordship the BISHOP; The Chief Justice, (Sir CONRAD REEVES, Kt.); The Acting-Colonial Secretary, (Hon. W. H. GREAVES, Q.C.); The President of the Legislative Council, (Hon. Sir GEORGE C. PILE, Kt.); The Colonial Treasurer (W. L. C. PHILLIPS, Esq.); The Chancellor of the Diocese, (FOSTER ALLEYNE, Esq.); The Very Rev. Dean PHILLIPS; Hon T. KERR, C.M.G.; Acting-Attorney General, (G. A. GOODMAN, Esq., M.C.P.); J. G. AUSTIN, Esq., M.C.P.; H. W. REECE, Esq., M.C.P.; R. HAYNES, Esq., M.C.P.;

G. LAURIE PILE, Esq., M.C.P.; J. P. MASON, Esq., M.C.P.; Canon GREAVES; Major KAYE: R. J. CLINCKETT, Esq., M.C.P.; Dr. J. R. PHILLIPS, M.C.P.; J. T. JONES, Esq., M.C.P.; Hon. W. P. LEACOCK, M.L.C.; E. F. S. BOWEN, Esq.: Dr. T. LAW GASKIN and a large gathering of Planters, Heads of Departments and Members of the Agricultural Society.

The following visitors, not resident in Barbados, were also present.

Sir C. C. KNOLLYS, K.C.M.G., Colonial Secretary of Trinidad; H. de R. WALKER, Esq., and Mrs. WALKER of England; Hon. G. T. FENWICK, M.L.C., of Trinidad and CHARLES DE MERCADO, Esq., Member of the Board of Agriculture, Jamaica.

The Representatives were received in the Hall of the House of Assembly at 10.30 a.m. by His Excellency the ACTING-GOVERNOR, who opened the Proceedings by the following speech:—

I am peculiarly privileged in that it is my lot to bid the Representatives from the various Colonies welcome to-day. Barbados is happily placed, because it has been held to be in all respects the most convenient Colony to receive the Representatives when they come to the Annual Agricultural Conferences. It may perhaps have some other claim as being the oldest Colony, and the mother Colony of the West Indies.

The formation of the Imperial Department of Agriculture is due to the recommendation of the Royal Commissioners supported by a vote of the House of Commons. I know that the Department has been of the highest value because it has encouraged research, for although some may have a wide knowledge of practical Agriculture—very wide in Barbados—there is no doubt that sugar planters in the past did not put their heads together and use all the means in their power to improve their industry.

We have now arrived at a time when we must appreciate and employ the most modern methods if we are to succeed in what we are doing. Dr. Morris has come amongst us, not to dictate to us, but to work with and advise us. I have heard it said by planters that this seedling or that is not so good as their own. The line, I hold, that Dr. Morris is taking is to put forward the best he can, and to encourage others to put forward the best they can in every department of work. He is just as ready to accept as he is to give, his general aim being to promote the best interests of the West Indies by the best methods that may be ascertained by thorough and exhaustive research.

With regard to agricultural education, I think we all need education. I trust I shall not give offence by saying that even the old planters need education. We need education if only in receiving hints as to the new order of things. When we talk of educating the people, let us remember that we propose to educate all from the highest to the lowest. I do not look for the advent of the Golden Era, but I do not think that on that account we should fail to encourage agricultural education. The young men of to-day who are to be

the managers of the future must certainly receive a sound agricultural education. There is just one other point to which I would draw attention. I do hope that we shall not lose sight of Central Factories throughout the West Indies. The question of Central Factories is of vital importance. A successful industry in every Colony is a necessity of Government, because, without successful industries, Governments cannot live. I hope, therefore, that this matter will not be allowed to drop owing to a slight temporary prosperity.

I must apologize for detaining you so long, and again welcome you here, and thank you for honouring this Colony with your presence.

THE PRESIDENT'S ADDRESS.

Dr. MORRIS then rose and said:

In opening the third West Indian Agricultural Conference to-day I have pleasure in announcing that the number of Representatives is larger than on any previous occasion. There are amongst us those whose position and experience are calculated not only to strengthen our deliberations but to render them as effective as possible in dealing with the various agricultural interests of these Colonies.

We especially welcome those who have not previously joined our ranks. On the Educational side, we welcome His Lordship the Bishop of Barbados, Chairman of the Education Board in this Colony; the Hon'ble Thomas Capper, the Superintending Inspector of Schools at Jamaica, and Mr. C. M. Martin, the newly appointed Inspector of Schools, for the Leeward Islands. On the Scientific side, Mr. Herbert H. Cousins, the recently appointed Government Analyst and Agricultural Chemist at Jamaica, the Author of "Chemistry of the Garden;" Mr. C. H. G. Sprankling, lately appointed Assistant at the Government Laboratory for the Leeward Islands, and the return amongst us, of Dr. H. A. Alford Nicholls, C.M.G., the Author of "Tropical Agriculture." Amongst the Representatives of Agricultural Societies, we welcome Mr. T. H. Sharp, Vice-President of the Agricultural Society of Jamaica, who has for many years taken a leading and useful part in the development of local industries in that island; Mr. Frederick J. Scard representing the Royal Agricultural and Commercial Society of British Guiana; Mr. Louis Bert de Lamarre representing the Trinidad Agricultural Society; Mr. Frederick Harford representing the Grenada Agricultural Society and Mr. Donald McDonald representing the Antigua Agricultural Society.

There is also present Mr. W. K. Morrison whose services have been temporarily engaged by the Imperial Department of Agriculture to encourage bee-keeping as a remunerative industry in certain localities in these islands.

The fact that so many able and distinguished men are gathered together for the object of actively and unitedly dealing with problems connected with the material prosperity of these Colonies is a memorable event in their history. The component parts of this Conference consist, first of all

of a band of men highly qualified in their several departments and specially skilled in dealing with scientific problems awaiting solution, and secondly, of those possessing an intimate acquaintance with the practical side, in fact, leaders in their own particular branch of industry, capable of assimilating the results of scientific research and of rendering them immediately available to improve the cultivation and preparation of agricultural produce, and render it of greater value to the producer. In a third section, we have representatives of the various educational agencies in the West Indies who bring with them the experience of all grades of schools from the highest to the lowest. We must perforce join our efforts with theirs, or, in our endeavour to improve Agriculture in the West Indies, we shall be continually thwarted by want of intelligence and lack of appreciation on the part of those we hope to benefit. Our conjoined aim should be so to educate, according to his station, the peasant and the planter, and to give to each the particular training and knowledge necessary to equip him for the battle of life.

We start with the fundamental idea that those who have to depend on the cultivation of the soil as the sole means of existence should, at least, be taught to observe and study intelligently the every day facts of rural life and to clearly comprehend the cardinal principles underlying the most important agricultural operations. By adding a reasonable amount of teaching in Science and Agriculture to the curriculum of their schools our educational colleagues will, I believe, widen the scope and add to the interest of their own work.

After these preliminary remarks it is desirable to glance at the business to be brought before us at this Conference. You will observe from the Programme of Proceedings that the papers are arranged under three heads: (1) those relating to the Sugar industry (2) those relating to Educational subjects and (3) those dealing partly with Other industries than sugar and partly with subjects less directly of an Agricultural character. I attach great importance to the papers dealing with the diseases of plants. Everywhere in the West Indies planters are confronted with the prevalence of insect and fungoid pests, in some cases, seriously affecting their crops, and often causing disappointment and loss.

In view of the increase in the number of Representatives, it has been sought to limit the number of papers in order to admit of fuller discussion. I trust that those in a position to contribute to the discussion on matters within their own knowledge and experience will not hesitate to do so.

Last year a Chemical Section was formed to take into consideration points of special interest to Chemists, but not generally interesting to others. This plan has proved so useful that it is proposed, from time to time, to form other Sections. Possibly an Educational Section could be formed this year. Our time is so limited that you will agree with me it is important to economise it as much as possible.

SUGAR INDUSTRY.

During the past year the series of experiments started in the various Colonies for improving the cultivation and yield of the sugar-cane have shown distinct progress. Reports, giving the results of experiments at Trinidad, have been published by Professor Carmody and Mr. Hart; at Antigua and St. Kitts by Mr. Francis Watts, Mr. Shepherd and Mr. Lunt, and at Barbados by Professor d'Albuquerque and Mr. Bovell. The experiments at British Guiana are being continued by Professor Harrison and Mr. Jenman, and it is hoped that experiments on similar lines will shortly be started by Mr. Cousins and Mr. Fawcett at Jamaica. It is important that, in addition to a Central Station, there should be a series of Experiment Stations in typical localities where selected canes could be tried under estate conditions and all fully tested by the official Chemist-in-charge. This plan will yield results in every way more reliable and more satisfactory than any single Station however well equipped.

I am glad to find that useful experiments are being carried on in some Colonies by planters themselves. In this connection I would mention those in irrigation now being tried by Mr. H. E. Thorne at Sandy Lane in this island. Great interest is being taken in the experimental cultivation of new seedling canes for the purpose of increasing the yield of sugar as well as of selecting varieties suited to withstand the attacks of borer and fungus. With reference to the statement that certain varieties are more resistant to disease than others, it has been noticed in British Guiana, for instance, that "over 50 per cent. of the Bourbon variety have been attacked by fungus and less than 10 per cent. of other varieties in the same field." Again, as the result of observation at Antigua, Mr. Watts is of opinion "there is every reason to hope that rind fungus may be effectively fought by the selection of new varieties of canes." The experience at Barbados, where new varieties are extensively planted, confirms this. The rind fungus is probably, at the present time, less destructive here than anywhere else in the West Indies. The results of the experiments with seedling and other canes will be the first subject to be dealt with to-day. I need only briefly refer to them here. I believe there is a reasonable hope of our being able to increase the sugar contents of the cane and eventually of placing within reach of the planter canes that will not only yield 40 to 50 per cent. more sugar than at present, but will also, if placed under suitable conditions, withstand to a considerable extent the attacks of disease. In support of what is above stated I cannot do better than direct your attention to the "Summary of the Results of the Cultivation of Seedling and Other Canes at the Experiment Stations at Barbados in 1900," already published in pamphlet form. These are the results of one year only, but they are of great interest and importance.

The best cane, so far, at Barbados is known as B. 147 which, compared with the White Transparent cane as a standard, has yielded according to the careful investigations of Professor d'Albuquerque and Mr. Bovell "44 per cent. more

marketable sugar" and "over 50 per cent. more saccharose" than the standard cane. The average weight of canes given by B. 147 was 27·5 tons and the available sugar was at the rate of 3·31 tons per acre. It may be added that B. 147 has now been cultivated at Barbados for more than seven years. The present area planted with it is estimated at about 1,000 acres. The canes which gave the results, so fully and graphically detailed in the pamphlet above referred to were grown at seven Experiment Stations by the planters themselves and under exactly the same conditions as other canes. At Antigua the cane that has so far yielded the best results is D. 95, of a dark purple colour, raised originally at British Guiana. According to experiments at seven Stations in 1899-1900, Mr. Watts states "this cane has exceeded all the others in sweetness of juice and in weight of canes. It now remains to be seen if, upon continued cultivation, it remains free from disease. If so, it will be desirable to cultivate it extensively." The average weight of cane yielded by D. 95 was 25·6 tons; and the available sugar in the juice was at the rate of 3·5 tons per acre. It is hardly necessary to remind the members of this Conference that the results above quoted apply only to the conditions existing at Barbados and Antigua. It is impossible, without actual trial, to forecast results that may be obtainable elsewhere. It is probable that in each Colony, and even in each district of a Colony, entirely different canes will be required to exactly suit local conditions.

It will be within your recollection that last year I drew attention to the fact that, side by side with the raising of new canes and improved systems of manufacturing sugar, it was necessary to consider the possibility of reducing the cost of cultivation. This, it was suggested, could be done by raising larger supplies of good pen manure under cover, by the more skilful use of artificial manures, by extending the growth of leguminous crops for green manuring, and by growing to a larger extent than at present the foodstuffs and supplies imported from other countries. It would appear that what has been described as "a sentiment of aristocracy" once associated with British Agriculture is not unknown in these Colonies. This, no doubt, is responsible for the survival amongst us of not a few unscientific practices and for the reluctance to make changes in harmony with the times. As was shown by Mr. Bovell last year, Barbados pays about £175,000 a year for foodstuffs, most of which could be produced in the island itself. In the olden days when sugar was £25 per ton, the practice of importing foodstuffs was economically sound, but now, with sugar at £12 per ton, it is a suicidal policy to purchase dear American foodstuffs with cheap sugar. This is probably one reason why the imports into Barbados, are over two million sterling in excess of the exports. To be in a healthy condition they should indeed be entirely the other way. Similar remarks, as shown in the Report of the Royal Commissioners, apply, but in a lesser degree, to Antigua and St. Kitts.

In the sugar islands of Barbados, Antigua and St. Kitts

the situation in regard to Central Factories shows, I regret to say, no advance whatever on what was so clearly placed before you last year by Mr. F. J. Clarke and Mr. Francis Watts. An effort to start a pioneer factory at Barbados by private enterprise has not, so far, been successful. At Antigua where the local conditions are probably more favourable for concerted action, the subject has again been fully discussed with the result that if money could be provided at a low rate of interest, a factory turning out about 5,000 tons of sugar, annually, could no doubt be started with every hope of success.

OTHER INDUSTRIES.

The important cacao industries at Trinidad, Grenada, St. Lucia and Dominica are in a comparatively prosperous condition. Possibly no other industry is so favourably situated at the present time. There is some anxiety, it is true, in reference to the "thrip" disease at Grenada, and fungoid diseases are also present on estates more or less in all the islands. With skilful cultivation and prompt action on the part of planters these pests, I believe, are all capable of being kept in check

I fear the prevailing tendency amongst cacao planters is to accept high prices and good crops without the obvious duty of giving back to the estates all that is necessary to maintain them in a thoroughly productive condition. This policy, if followed, is distinctly short-sighted, as in the event of a fall in prices the result would be crippling to the industry.

The lime industry in Dominica, and in one or two other Colonies has increased in value, and, like cacao, deserves to be fostered and improved.

An attempt is being made to establish an industry in raising early potatos for the English market. Experiments are being carried on by the Imperial Department of Agriculture in several islands with imported English seed, under advice obtained from one of the largest potato merchants in the United Kingdom.

A small, but very successful, onion industry is being carried on at Antigua. A paper will be presented by Mr. Sands on the subject. It is, however, not sufficient to raise produce, but, also, to find a suitable and remunerative market for it. Planters should look well in advance and harvest their produce at the most favourable time, and present it in exactly the right condition to suit local as well as foreign markets.

Mr. Hart will read a paper on the cultivation of rubber trees and indicate the progress so far attained in the West Indies.

Fruit cultivation is not being extended in any of the smaller islands. At Jamaica, the establishment of a Direct Fruit Service between that island and the United Kingdom cannot fail to arouse interest in the capabilities of the West Indies to supply oranges, bananas, and pineapples in large quantities to European markets. Unfortunately, the present steamer facilities outside Jamaica are entirely unsuited for a regular fruit trade.

AGRICULTURAL EDUCATION.

During the last year, Lectures to Teachers in charge of Elementary Schools have been successfully carried on in every part of the West Indies. Those that have come under my notice from Jamaica and Trinidad are distinctly promising. Sir Alfred Moloney took a warm interest in those delivered in the Windward Islands under Mr. Howard, and Mr. Watts has given valuable assistance in those in the Leeward Islands. Mr. Whitfield Smith gave the lectures at Montserrat and the Virgin Islands. Within another year or two, in the smaller islands at all events, every teacher in charge of a school should be qualified not only to give a certain amount of instruction in the principles of Agriculture, but to interest his children by simple experiments, followed by practical demonstrations, in the cultivation of plants suited to each district. The plants may be grown in pots or boxes or on small plots attached to the schools. This work must necessarily progress slowly, and be carried on with the hearty co-operation of all concerned. I fully realize the difficulties to be overcome, but, provided we proceed after due deliberation and keep clearly in view the fact that we cannot attempt to teach practical farming to children in Elementary Schools, we shall be on right lines.

Seven scholarships in Agriculture, tenable at Harrison College, have now been awarded by the Imperial Department of Agriculture. Two scholarships of the annual value of £75 each have just been awarded in the Windward and Leeward Islands.

The first Agricultural School in the West Indies, affording secondary education to selected boys who may afterwards become managers of estates or cultivate their own lands, was opened at St. Vincent in September. A similar Agricultural School was opened at Dominica in December last. It is hoped that two more Agricultural Schools will be opened this year, one at St. Lucia and another, combining the characters of an Agricultural School and a Grammar School at St. Kitts. It will be observed that the scheme of agricultural education outlined above is directed to reach every section of the community.

BOTANIC AND EXPERIMENT STATIONS.

During the year three new Experiment Stations have been established at Montserrat, and one at Tortola for the Virgin Islands. At the present time, there are nine Botanic Stations maintained from Imperial Funds under the charge of the Imperial Department of Agriculture. In addition, there are twenty sub-stations, or Experiment plots started at Grenada, St. Vincent, St. Lucia and Dominica to encourage the improved cultivation of cacao, coffee, limes and other crops. There are twelve Central, Manurial and Local Stations associated with the sugar-cane experiments at Barbados; seven similar Stations at Antigua, and three at St. Kitts-Nevis. Experimental cultivation, with food and other crops, will be carried on in connection with all the Agricultural Schools.

AGRICULTURAL SHOWS.

As a means of encouraging the better cultivation and preparation of produce these shows have already proved of value. At St Lucia, Dominica and the Virgin Islands excellent shows have been held on exactly the lines best calculated to bring into notice the resources of the islands and to create an intelligent interest in prosecuting new industries and improving those already existing. About £350 have been distributed in prizes by the Imperial Department of Agriculture and 100 "diplomas" have been awarded in cases of special merit.

TREATMENT OF DISEASED PLANTS.

Papers will be read dealing with insect and fungoid diseases of the sugar-cane and other plants. This subject has already occupied a considerable share of the attention of the officers of the Department of Agriculture. Recommendations are being given to enable the planters to deal with pests as they arise. It is evident that we are not yet in a position to formulate a general scheme of legislation on the subject.

An ordinance based on the Queensland Act was passed by the Legislature of Grenada in November last, entitled "Agricultural Interest Protection Ordinance, 1900." This ordinance is intended "to prevent the introduction and to provide for the eradication of diseases affecting vegetation and for other purposes." It is primarily intended to protect the cacao industry but it may be made applicable to other industries.

As regards the advisability of providing compulsory powers to deal with the diseases of the sugar-cane I cannot do better than quote from a letter from Mr. Francis Watts as follows:—

"In the present state of our knowledge I am not very favourably inclined towards compulsory legislation directed towards the eradication of cane diseases: but if legislation is, by others, thought necessary I think that an Act should be passed providing for the inspection of all fields of canes, that the duties of the inspector should be largely advisory and partly directed towards seeing that the planters conform to certain methods and rules under penalties for neglect. That the inspection and reports should be on lines laid down by the Imperial Department of Agriculture. That the Act should contain a schedule for such things as are to be made compulsory, and the Governor, or Administrator, in Executive Council should have power to alter this schedule from time to time as necessity arises. At present the only things which I believe it possible to *compel* planters to adopt are the cutting out of dead-hearts and the burning of rotten canes. There should be a definite limit of 3 or 5 years to the period for which the Act is to be in force; if desired, it can easily be re-enacted at the end of that period. The cost of working the Act can be put down at say £250 a year for St. Kitts only, and this sum should be provided specifically by the sugar estates. If this is to be made up by a tax on cane lands it will mean about 5d. per acre."

In conclusion I may mention that while the work of the past year has been of a singularly laborious character and many unexpected difficulties have arisen to hamper our progress I entertain strong hopes that, before long, we shall see tangible results of our efforts.

Dr. Nicholls, C.M.G. (Dominica): It affords me much pleasure to comply with the request of several members of this Conference that I should propose a vote of thanks to the President for his extremely able, interesting and satisfactory address. Dr. Morris has told us that it is necessary to economise time as much as possible, therefore what I have to say will be put in a few words. The President's Address really crowns the work of the Imperial Department of Agriculture for the past year · for it is not until the address has been delivered that the work of the new year commences. It is, therefore, advisable that we should turn our thoughts to the nature and result of the work undertaken in the past. So that, in thanking the President for his address, we must also thank him for what has been accomplished for the present benefit and future prosperity of these Colonies by the incessant and plodding work of Dr. Morris and the band of able specialists around him. We are at the parting of the centuries, and I think I may say that the dawn of the new century is a bright one for the West Indies, and we must recognise that the brightness of this dawn is due in a great measure to Dr. Morris and those associated with him in his work. I may perhaps be allowed to say this much, for I am in no way connected with the Department of Agriculture. I speak apart from official work, but I have had special opportunities of recognising its value, and I am satisfied that you will all agree with me that that work has tended to improve these islands. I cannot, perhaps, speak positively concerning the affairs of the sugar producing islands, but with regard to those Colonies depending on the so-called, and wrongly called "minor" industries, the work of the Department has done a great deal, and promises to do much more in the future for their prosperity. Therefore, I have extreme pleasure in proposing that the thanks of this Conference be accorded to Dr. Morris not only for his address but also for his work during the past year.

Mr. Donald McDonald (Antigua): I have the honour and pleasure of seconding the vote of thanks to our President, Dr. Morris, for his most interesting and comprehensive address. The time is so short that I will only say that on listening to that address one is more than ever convinced that those entrusted with carrying out the work of the Imperial Department of Agriculture under Dr. Morris may have two drawbacks to contend against. There is so much to be done that they will probably find that time will fail them in their endeavour to keep up with and follow the many excellent suggestions put forth for the good of the West Indies, and energy may fail them in emulating Dr. Morris' desire for work for the benefit of these islands.

After the retirement of Visitors the Conference proceeded with the business of the day.

II. SUGAR INDUSTRY.

(I) Professor D'ALBUQUERQUE opened a discussion with a paper on "Recent Experiments with Seedling and other Canes" with special reference to Barbados. Mr. J. R. BOVELL gave a brief historical sketch of the various seedling and other canes experimentally cultivated at Barbados during the last twelve years.

Professor CARMODY summarized the results of sugar-cane experiments at Trinidad and Mr. J. H. HART followed, giving interesting information as to the characteristics of new canes at the St. Clair Experiment Station at Trinidad. The discussion was continued by Mr. FRANCIS WATTS (Antigua), Mr. W. FAWCETT and Mr. T. H. SHARP (Jamaica), Mr. G. S. HUDSON (St. Lucia), Mr. F. R. SHEPHERD (Antigua), and summarized by the PRESIDENT.

(II) Professor CARMODY read a paper on "Cane Farming at Trinidad" showing the progress of the industry and offering suggestions for its improvement and extension. In the discussion that followed Mr. F. WATTS (Antigua), Mr. G. S. HUDSON (St. Lucia), Mr. W. FAWCETT (Jamaica), Mr. A. J. JORDAN (Montserrat) and others took part.

The Conference then adjourned for luncheon.

(III) After luncheon Mr. H. MAXWELL-LEFROY, Entomologist to the Imperial Department of Agriculture, read a paper on "Insect Pests of Sugar-Cane" illustrated by drawings. Mr. MAXWELL-LEFROY gave a brief account of three of the more important pests affecting sugar cane estates in the West Indies, and very clearly and forcibly described the measures likely to be successful in dealing with them. The paper was well received and led to an interesting discussion, in which Mr. F. WATTS (Antigua), Mr. F. J. CLARKE (Barbados) and Mr. F. R. SHEPHERD (Antigua) took part.

(IV) Mr. ALBERT HOWARD, Lecturer in Agricultural Science at Barbados, contributed a paper on "Fungoid diseases of Sugar-Cane." In this paper Mr. HOWARD brought forward several valuable suggestions in regard to the habit and treatment of the rind fungus (*Trichosphaeria sacchari.*) In the discussion which followed the PRESIDENT, Mr. W. FAWCETT, (Jamaica), Mr. W. D. SHEPHERD (Barbados), Sir GEORGE C. PILE (Barbados), Professor CARMODY (Trinidad), Mr. F. WATTS (Antigua), and Mr. HART (Trinidad) took part.

III. EDUCATIONAL.

(V) The Rev. Canon SIMMS (Jamaica) presented a paper, read by Mr. THOMAS CAPPER, on "Agricultural Education and its place in General Education." The author described very ably and fully the place agricultural education should take, beginning with the Elementary Schools and gradually develop-

ing, stage by stage, to the High Schools and Colleges, also the danger which should be avoided in each case. The paper was discussed by Mr. J. A. POTBURY (British Guiana) and the PRESIDENT.

(VI) The Hon'ble THOMAS CAPPER (Jamaica) read a very interesting paper on "Teaching the principles of Agriculture in Elementary Schools," in which he described the efforts now being made to introduce the teaching of Agriculture into the Elementary Schools of Jamaica. He quoted some of the provisions of the Code of Regulations of the Education Department in that island that came into force on May 10, 1900, and generally supported the view that while agricultural education was possible on certain lines it would require a considerable time to organise an effective system in an island where the teachers numbered over 700 and the distances to be covered were so considerable. The Rev. J. E. REECE (Barbados) and Mr. WILLIAM BLAIR (British Guiana) contributed short papers bearing on the same subject.

The Conference then adjourned until 9.30 a.m. on Monday.

CONFERENCE DINNER.

The members of the Conference dined together in the spacious dining-room of the Marine Hotel at 8 p.m. on Saturday, 5th January. The President of the Conference (Dr. MORRIS, C.M.G.) was in the chair. Covers were laid for fifty-two, and besides all the leading members of the Conference and Dr. Morris' official staff, the following guests were present:

His Excellency, the Hon'ble RALPH C. WILLIAMS, C.M.G., Acting-Governor; His Lordship the BISHOP; Hon'ble W. H. GREAVES, Q.C., Acting-Colonial Secretary; Hon'ble F. J. CLARKE; Rev. Canon BINDLEY; J. GARDINER AUSTIN, Esq., Chairman of the Chamber of Commerce; W. A. HORNE, Esq., Superintendent of the Colonial Bank; Captain OWEN, Superintendent of the Royal Mail Steam Packet Company; Lieutenant Colonel ST. LEGER; H. de R. WALKER, Esq.; FOSTER M. ALLEYNE, Esq., Chancellor of the Diocese; and Lieutenant CLAUDE HAMILTON, A.D.C.

Dinner over.

Dr. MORRIS rose and proposed "The health of Her Majesty the QUEEN and the Members of the Royal Family," remarking that her Majesty was herself an ardent Agriculturist.

The toast was drunk with the accustomed honours.

His Excellency the ACTING-GOVERNOR, then rose and said: My Lord and Gentlemen: The Imperial Department of Agriculture is a term well known to us now, but lately it was almost unknown. When the West Indian Royal Commissioners came out here, they saw that what was necessary was an

insight into the several industries, and with great wisdom they recommended that a Central Department should be established in the West Indies around which all existing organisations might cluster. In the smaller Colonies perhaps there were few organisations, for many reasons which I need not go into. In the larger Colonies, there were large organisations which had done good work in the past, but that was no reason why there should not be the supreme central organisation, which we now have in the Imperial Department of Agriculture. (Cheers.) When we regard the Mother Country, we should be grateful to the Government and Mr. Chamberlain for what has been done. I think something like £17,000 a year is spent on this work, and you can easily understand what strong pressure must have been brought to bear on the Treasury before the West Indies could get the benefit of the Imperial Department of Agriculture. Perhaps it is not out of place for me to say how much has been done in the West Indies, not only in the formation of this Department, but by the subsidising of steamers and so forth, which, on the whole, I think is costing the Imperial Government not much less than £100,000 a year. That, surely, is a fair answer to the question sometimes asked: "What does the old country care for the West Indies to-day?" But to go back to the Department of Agriculture, and what it has done If it has done nothing else, it has done a good deal in gathering around us to-night, and a year and two years ago, competent and capable representatives of the various industries of the several West Indian Colonies, and British Guiana. (Cheers.) It is not merely a question of good with regard to one Colony, but what it does to all the Colonies. I know as well as any one the very considerable difficulties met with by Dr. Morris in his work. We are fortunate in Barbados that he has his headquarters here, and we know how closely he devotes himself to his work. Speaking as the representative of the Government, I can say that the Government of Barbados have found Dr. Morris a capable coadjutor in all that concerns the welfare of the Colony. He strenuously studies the interests of his Department, because he feels that the welfare of the Department is the welfare of the West Indies. I have never met anyone who is more capable to serve as the head of the important Department to which he belongs. (Cheers.) I have also had opportunity of watching the various members of the department who are in Barbados, and I know that Dr. Morris has made a good choice of gentlemen who are able to second his efforts. Further, as travel about, I hear that wherever the Department of Agriculture is, its influence is felt for good in the Colonies. It is singular that at first the poorer classes mistrust the efforts made in their behalf. That is unfortunate, and I think that what all of us should do is to drive away from the people the idea that the Imperial Department of Agriculture comes among them for anything but the improvement of their condition, and to make them better than they were before. Then with regard to cane cultivation, I think it is fair to ask that all gentlemen interested in the cane industry should join with the Department in lending it

assistance, in giving it land for carrying on experiments, and in giving it the fullest information as to results; because unless full information is given to the Department, it is impossible for it to get together those statistics by means of which it may best help the community. I think everyone in these Colonies will recognise that in appointing Dr. Morris, Mr. Chamberlain has had their best interest at heart. The Department has done its work well, and, with regard to Dr. Morris, the motto which belongs to him is—"Whatever thy hand findeth to do, do it with thy might." With these remarks, I propose "The health of Dr. Morris and success to the Imperial Department of Agriculture in the West Indies." (Cheers.)

The toast was drunk with the utmost enthusiasm.

Dr. MORRIS, in responding said: I am extremely glad to have the opportunity to thank, not only those present, who are closely associated with me in my work, but others in the various Colonies, who help me in what I have to do. I thank your Excellency for the kind way in which you have spoken of the Department of Agriculture and the officers connected with it. As this is the first opportunity offered to us, I venture to express the extreme pleasure we all feel that Her Majesty the Queen has been pleased to recognise your labours in various parts of the Empire. (Cheers.) We are confident that the distinction now conferred upon Your Excellency has been well deserved. With regard to the Department of Agriculture, I can only say that year by year I feel more hopeful that the work entrusted to the Department will ultimately prove of great benefit to these Colonies. At every succeeding Conference, those associated with me are proving year by year more loyal and helpful in the work I have to undertake. To those who have travelled, in some cases, more than a thousand miles, in order to assist us with the results of their knowledge and experience, I am most grateful, and still more for the hearty and thorough manner in which they have assisted in the business of the Conference. No one could have more earnest and capable colleagues than happily I have. I am convinced that if, in addition, the Department could secure the cordial support of all classes of the community, it would perform a great work. I heartily thank Your Excellency and all present for your kindness, and I need only add that, as far as my strength permits, I am determined to make the Imperial Department of Agriculture of benefit to all parts of the West Indies. (Cheers.)

Mr. J. H. HART, F. L. S.: As the oldest member of the Botanical Service who has served under Dr. Morris, beginning nearly twenty years ago, it is my privilege to assure him of the loyalty and goodwill of every member of that service. He will never lack any support we can give him. We regard him as a man of resource, of infinite tact, a man of sound judgment, and one that attains to success in everything he undertakes. We are prepared to do everything we can to make his work a success for the West Indies. (Cheers).

His Lordship the BISHOP: I have been asked to propose a toast which I am sure will be drunk with a very great deal of

pleasure. It is the health, long life and prosperity of the Representatives and Visitors to this Conference. I, as a resident in Barbados, am very glad, indeed, to welcome the Representatives of the various Colonies to this, our little island. There is a good deal of go aheadedness in Barbadians when they take a thing into their heads, but when they do not like a thing there is a good deal of un-go-aheadedness in them too. We all want to be taught what is good for Barbados - I am speaking particularly as President of the Education Board and are anxious to know what is best for the people of this Colony. We are proud that Barbadians should be so honoured by having such competent and intelligent Representatives coming to the Island, and I now propose the health, long life and prosperity of those Representatives and Visitors, coupling with the toast the names of Professor Carmody of Trinidad, Mr. T. H. Sharp of Jamaica, and Mr. H. de R. Walker a visitor from England. (Cheers.)

The toast was drunk with enthusiasm.

Professor CARMODY, in responding said: It is a pleasure for me to say that the Representatives are always well received when they come to Barbados, and they always will be. (Cheers.) I say this because I have observed that hospitality in the West Indies has been closely associated with the sugar industry, and wherever the sugar industry is predominant there hospitality is predominant. In Barbados, the sugar industry is always predominant and therefore, hospitality is predominant. To turn to the serious side of our work, I will make one remark. I have heard it said on more than one occasion that there is a considerable amount of apathy shown on the part of agriculturists with regard to the work done by the Imperial Department of Agriculture. I think we should sink all petty differences and have one object in view, and that is, to combat the beet industry. If we make up our minds to do that, I am sure that the cane sugar industry will always be a flourishing one. (Cheers.)

Mr. T. H. SHARP: When I left Jamaica to come here I had no idea of the hospitality which would be extended to us. I do not allude to the hospitality around us now, but to the mental repast which we had at the Conference, and which, I am sure, no one appreciated more than I did. Unfortunately for us in Jamaica, when the arrangements were made by the Imperial Government for the formation of a Department of Agriculture in the West Indies, Jamaica was practically left out in the cold. Her resources being large, she was thought to be able to do without the assistance of the Agricultural Department. But I have so deeply appreciated what has passed to-day that I shall never rest until I see the day when we shall come more directly under the influence of that Department. There is no visitor here to-day, who has taken any interest in the Conference, who is not satisfied that he is more than amply repaid for the expense and trouble incurred in coming here. (Cheers).

Mr. H. de R. WALKER: I have only been here a short time and, practically, know nothing of the present situation and the condition of these islands. I have, however, been very much interested in what I have heard to-day, and I hope to spend the

next two months in visiting the different parts of the West Indies. I think you will all agree with me that, politics apart, you cannot have too many men in the House of Commons who have visited the Colonies, whatever their political ideas may be. (Cheers.) I have already spent many months in Canada, and a year in Australia and New Zealand, and, although I hope I shall not spend all my life in these parts, yet I think that a man who has spent some time here will not only help matters in the House of Commons, but will be able by his experience to do some good to the Colonies which he has visited. (Cheers.)

The party then separated.

III. EDUCATIONAL *(continued.)*

The Conference resumed at 9.30 a.m. on Monday, Dr. MORRIS presiding as before.

(VII) Mr. C. M. MARTIN, B.A., (Leeward Islands) read a paper on the "Results of ten years' experience with Compulsory Enactments in the Leeward Islands." He stated that compulsory education in the Leeward Islands dated from 1890 and gave figures showing the increase in school attendance since that time. He pointed out the desirability of having children of equal ages in each standard, and in conclusion stated that he saw no reason why compulsory education should not become general in the West Indies. In reply to questions put to him, Mr. MARTIN informed the Conference that the age limit for compulsory education was from 5 to 12 years, the fees were one penny per week, and the District Educational Officers throughout the Leeward Islands cost £370 per annum.

The PRESIDENT remarked that the success or failure of compulsory education would directly affect agricultural education -it formed, in fact, the basis on which all efforts would depend. He then announced that there would be a separate sitting of the Educational members of the Conference in the Council Chamber to consider certain questions relative to scholarships, the preparation of books to extend agricultural teaching, the issue of certificates to teachers in charge of Elementary schools, and kindred subjects.

The Educational Section thus formed then met in the Council Chamber with His Lordship the BISHOP as Chairman, and the Hon'ble T. CAPPER (Jamaica) as Secretary. A report on the results of the deliberation of the Educational Section will be presented later.

The main body of the Conference then proceeded with the business before it.

IV. GENERAL.

(VIII) Dr. H. A. ALFORD NICHOLLS, C.M.G., read a paper suggesting "Legislation to control Bush Fires." He explained that the further title was—Bush fires and their harmfulness to the soil in Colonies where they were not controlled by

Legislative enactment. The paper was listened to with great interest and led to an animated discussion. Mr. W. FAWCETT (Jamaica), Mr. F. WATTS (Antigua), Mr. T. H. SHARP (Jamaica), Mr. A. J. JORDAN (Montserrat), Mr. DONALD McDONALD (Antigua), Mr. G. S. HUDSON (St. Lucia), Mr. BERT DE LAMARRE (Trinidad) and the PRESIDENT taking part.

(IX) The Hon'ble FRANCIS WATTS (Leeward Islands) read a paper on "The treatment of Soils in 'Orchard' cultivation in the tropics." Mr. HART (Trinidad), Mr. W. FAWCETT (Jamaica) and Dr. NICHOLLS (Dominica) contributed additional information. In summing up the President recommended light forking and efficient drainage on sloping lands as the first requisites in permanent plantations in the tropics. He was not in favour of allowing grass to grow in plantations under any circumstances, but preferred to adopt the recommendation made by Mr. WATTS of cultivating leguminous plants, where possible, afterwards digging them into the soil to enrich it with humus and nitrogen.

(X) Mr. J. H. HART (Trinidad) read a very interesting paper on "Rubber Planting in the West Indies." In this paper all the different india-rubber trees suitable for cultivation in the West Indies were fully described, and their merits discussed. Mr. HART also exhibited specimens of rubber obtained from trees under experimental cultivation in Trinidad. Dr. NICHOLLS (Dominica), Mr. W. FAWCETT (Jamaica), and Mr. H. MILLEN (Tobago) took part in the discussion. The PRESIDENT closed the discussion with an account of his experience in connexion with the Castilloa rubber-tree and the rubber industry in British Honduras.

The Conference then adjourned for luncheon.

(XI) On re-assembling after luncheon the Honourable FRANCIS WATTS (Leeward Islands) read a paper descriptive of the "Pine-apple cultivation at Antigua." This industry, in spite of adverse circumstances, has existed for about 30 years. The quantity of fruit exported in 1899 was the largest on record, and amounted to a value of £2,051, of which £1,461 represented the value of fruit shipped to the United Kingdom. Mr. T. H. SHARP (Jamaica) followed with a very interesting account of the pine-apple industry carried on at Jamaica chiefly with the smooth Cayenne pine, in some cases producing fruit, weighing from 13 to 15 pounds. The PRESIDENT thanked both Mr. WATTS and Mr. SHARP for their contribution, and remarked that the latter gentleman especially had impressed him with the value of a thorough practical knowledge of the subject in hand.

(XII) Dr. J. E. DUERDEN (Jamaica) next read a comprehensive paper on the "Marine Resources of the West Indies." He graphically described the varied marine resources of the seas bordering these islands and remarked on the anomaly of importing salted fish to the extent of thousands of tons annually while the splendid fisheries of the West Indian waters were quite undeveloped. He pointed out that at the Cape the Agricultural Department supervised both the agricultural and

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marine resources. The PRESIDENT thanked Dr. DUERDEN for his paper but doubted whether, at present at least, Her Majesty's Government would permit the Imperial Department of Agriculture to take up marine biology in addition to its numerous other duties.

(XIII) Mr. W. K. MORRISON, Acting Bee-Expert on the Staff of the Imperial Department of Agriculture, then read an introductory paper on Bee-keeping, in the course of which he referred to the possibilities of the industry in the West Indies. The PRESIDENT explained that it was proposed to arrange for Mr. MORRISON to visit all the smaller islands during the next few months and advise Bee-keepers to the best of his ability. He was satisfied that in some localities the circumstances were very favourable to the success of a bee-keeping industry. At Jamaica the value of the exports of bees-wax and honey amounted to about £13,000 annually.

The following papers, owing to pressure of time, were taken as read :—

The Cultivation of Onions at Antigua. (Mr. W. N. SANDS.)

"Zebu" Cattle in Trinidad. (Mr. C. W. MEADEN and Mr. J. H. HART.)

Artificial drying of Cacao. (Mr. G. WHITFIELD SMITH.)

Fungoid Diseases of Cacao and other plants. (Mr. ALBERT HOWARD.)

Experiments in the treatment of Insect Pests in 1900. (Mr. H. MAXWELL-LEFROY.)

CONCLUSION.

The PRESIDENT: In bringing the business of the West Indian Agricultural Conference of 1901 to a close, the pleasant duty devolves upon me to express hearty thanks to you for coming here, and for the earnest manner in which you have taken part in the proceedings. I am of opinion that this Conference, as far as opportunity offered, has been entirely successful. Our time has been very limited, but, in spite of that, a number of important and useful papers have been brought before us and discussed by men who thoroughly understood their subject, and who, in each case, presented it in a lucid and interesting manner. We cannot have failed to obtain a large amount of valuable information, and to derive benefit in many other ways from intercourse with one another. A full report of the papers and discussions will shortly be published in the "West Indian Bulletin," the Journal of the Imperial Department of Agriculture. This Journal, I may mention, is not only widely distributed in these Colonies, but all over the world. It reaches workers in all branches of Agriculture. In return, we receive publications of great value. The work of these Conferences, and I may say of the Department generally, is watched with a good deal of interest by those engaged in similar efforts in other countries. I again thank you for your attendance, and wish you God-

speed in returning to your homes, and carrying on the work in which we all feel so deep an interest.

Mr. T. H. SHARP (Vice-President of the Agricultural Society of Jamaica) then rose and said: I am deputed to move a vote of thanks to Dr. Morris for organising and presiding over this Conference. I have come from a Colony not possessed of the privileges here available, that is, of having this Conference in our midst, so that planters and others can attend, and listen to the proceedings. This I regard as a great privilege. It is possible that the people of Barbados will never fully appreciate it until they have not got it. I have learnt more during the short time I have been here than I have for a long time. It is evident that to meet all the varying conditions of elevation, soil, and climate in these islands, it is impossible to have a stereotyped system of cultivation. Hence the value of the varied opinions obtained at this Conference, and the necessity for utilising latent talent, and of consolidating information and disseminating it throughout the West Indies. It is our duty to work harmoniously with these Conferences so that their influence may be felt as widely as possible. On behalf of those present, and those not present, I move a hearty vote of thanks to the President for the able manner in which he has conducted these proceedings. He has grasped every subject brought forward and discussed, and has guided the business with the greatest skill and attention. The responsibilities of Dr. Morris and his colleagues are enormous, and, in according him our thanks, I believe you will do so with the same enthusiastic and sincere feeling as myself. (Loud applause.)

Mr. J. H. HART, F.L.S. (Trinidad): I second the vote of thanks just proposed with great pleasure. Mr. Sharp has left me nothing to add, and I therefore content myself with formally, but heartily, supporting him.

The Hon'ble F. J. CLARKE: As one residing in Barbados, where the Department has its headquarters, I feel I ought to add a word of appreciation of Dr. Morris, and I do so more especially because of a remark made by him which seems to imply that the Barbados planters do not support his efforts by affording information asked for. I can assure Dr. Morris that if the planters do not give the facts he asks for, it is because they believe they have not got them to give. Further, the bulk of the planters in this Island do highly appreciate the services of himself and his staff, and fully recognise the good work they are doing here. (Applause.)

The PRESIDENT: I thank you most heartily for your kindness. The cordial appreciation given to the efforts of myself and my staff will greatly encourage us. I assure you that nothing will be wanting on our part to render the Imperial Department of Agriculture as efficient as possible in carrying out the duties entrusted to it. Before we separate, I desire, on your behalf, to express our thanks to His Excellency the Acting-Governor for his kindness in opening the Conference, and to the Governor-in-Executive Committee for the use of this Hall. Our thanks are also due to the Heads of Departments and others, including the Superintendent of the Royal

Mail Steam Packet Company, who have so readily assisted in arrangements for our comfort and to the Press for reporting the proceedings so fully, and, in other ways, supporting our efforts. In reply to Mr. Clarke, I may mention that the information desired from planters is really of a simple character, and not likely to give much trouble For instance, we, at present, have no data as to the area actually under cane in this Island, nor an approximate estimate even of the number of acres planted under each variety. The information required could, I believe, be readily given. It is desired not out of curiosity, but solely with the view of enabling us better to understand the position of the industry and render our services of greater value to the Colony. I think that is a fair ground on which to base our request. I trust this fuller explanation will enable the planters generally, but especially the leading attorneys, to assist us. In conclusion, Gentlemen, I once more tender you my best thanks for your presence and assistance.

AGRICULTURAL CONFERENCE, 1901.

(CONTINUED.)

Having in the previous pages given a brief Report of the Proceedings at this Conference it is now proposed to publish the principal papers read with a summary of the discussion in each case :-

RECENT EXPERIMENTS WITH SEEDLING AND OTHER CANES.

Professor D'ALBUQUERQUE : I have been requested by the President of this Conference to introduce a discussion upon seedling canes by indicating very briefly the main points contained in the Departmental Pamphlet, entitled "Seedling and other Canes at Barbados, 1900," the conjoint work of Mr. Bovell and myself.

In 1898, when the present experiments were started, we had some 100 varieties of very varying merit under experimental cultivation for the most part at Dodds. We came to the conclusion that, however well a seedling did at Dodds, it would be necessary to try that variety in different parts of the Island before recommending it to the planters. We therefore selected some eight of the best varieties and planted plots of each of them at seven estates situated in different districts of the Island. We cultivated two or three other varieties side by side with our selected seedlings for comparison. The experimental canes were, in each case, grown under the same conditions as those cultivated on the estates. Although during the year the Island experienced a long period of drought, the want of rain was much more severely felt at some estates than others, and this has in some cases accentuated the differences between the various stations, while in other cases it has tended to obscure those differences. Moreover, drought affects some varieties much more than others, so that some varieties that shewed to disadvantage this year would, under more favourable conditions, have given better results. Consequently, planters should not lay too much stress either on the results obtained with some particular cane at one station or on the general results of any single year. The average obtained after several years trial will be a much safer guide in selecting varieties for estate cultivation.

On pages 1 and 2, the methods employed in regard to the planting, reaping and analysis of the selected varieties are briefly indicated, and it will be noticed that we have employed the formula of Mr. Douglas, the Chemist of the Diamond Estate, in calculating what yield of marketable sugar we can expect to obtain at a fully equipped modern factory from juice of known composition.

On page 4, the chief questions to which the planter will seek replies are enumerated as follows :—

(1) Does it give a large tonnage of canes per acre?

(2) Is it a good milling cane, i.e., does it pass through the mill without breaking off, and does it yield a high percentage of juice?

(3) Is the juice rich in sugar?

(4) What is the degree of purity of the juice?

(5) Is the cane a healthy one or is it subject to disease, giving a large percentage of rotten canes?

(6) How long does the variety take to ripen?

(7) How does it stand drought?

(8) Does the seed cane (plant) germinate (spring) readily?

After this, follows a list of the stations, their respective elevations above the sea rainfall for the year and the average results obtained at each station upon all the plots of the station taken together. A detailed account of each cane giving both the field characters and the chief industrial results is also recorded.

Besides the tables at the end of the pamphlet giving the mean results at the Black soil Stations, Red soil Stations and all the Stations together, I have before me the results obtained at each of the seven Stations individually which will be published in our annual report. I have also some figures showing the number of years each seedling and older variety has been cultivated at Dodds, and their average yields from which the following data have been selected:-

B. 147 has been cultivated at Dodds six years (to 1899), and has given results there showing an average of 34·5 tons of cane and 3·95 tons of sugar per acre estimated by the Douglas factory formula. In this year's experiments the average results were 27·5 tons of canes and 3·1 tons of sugar per acre.

B. 347 was cultivated at Dodds two years (to 1899) and gave 10·2 tons of cane and 1·5 tons of sugar per acre, estimated by the Douglas formula. This year the average results were 26·7 tons of cane and 2·6 tons of sugar per acre. The difference between these results and those obtained at Dodds alone is very striking.

The Jamaica cane and the Rock Hall cane cultivated two years (to 1899) at Dodds, held a high place on the list at that station, while the Jamaica cane has retained a high place in the experiments of this year. The Rock Hall cane, owing probably to drought, has shown a marked falling off.

On pages 15 to 17, a comparison is made between the results obtained with White Transparent and B. 147 on three estates where they grew in the same fields. The results are decidedly in favour of B. 147. The White Transparent cane is now by far the most widely cultivated variety in Barbados, and the above mentioned comparative results, together with the general average at all the stations, lead us to recommend planters in this Island to give B. 147 a careful trial. Unfortunately, it has not shown good ratooning power in the usual ratooning districts, and this will lead planters in Red soils to be cautious in the extent of their trial. We are also of opinion that the results so far obtained warrant our recommending B. 208, B. 306, B. 156, B. 347 and the Jamaica cane as worthy of careful and

limited estate trial. Of these, B. 147, B 306 and B 156 will require care in the muscovado boiling house. It will be interesting to hear from the workers in other islands what conclusions they have arrived at from their experiments. We are aware that B 147 has not done so well in other places as it has in Barbados. It is not to be expected that one variety will be the best everywhere, but that different canes will be preferred in different localities.

Mr. J. R. BOVELL (Barbados): At the request of the President I have prepared a brief sketch of some of the seedling and other canes that have been experimentally tried at Barbados during the last sixteen years. In 1884, at the suggestion of Sir William Robinson, we received from Dr. Morris, then in charge of the Botanical Department of Jamaica, plants of twelve different canes then under cultivation in that island. Amongst these were Mauritius, Keni-Keni, Norman, Naga, Sacuri, Hillii, Mamuri and Elephant. Other canes were subsequently introduced from British Guiana sent by Mr. Jenman, from Trinidad sent by Mr. Hart, and the Caledonian Queen from St. Kitts sent by Captain Berkeley. In January 1888 we took up the cultivation of self-sown seedling canes found at Dodds. These had been previously noticed by planters in the Island but their systematic cultivation was not taken up until the date abovementioned.

The first cane of promise among the self-sown seedlings obtained in 1888 was named Burke, after the overseer who discovered them. This cane gave excellent results at Dodds when compared with the Bourbon, and as tentative cultivation at Stepney and other estates confirmed these results, it was in 1895 somewhat extensively cultivated on various estates all over the Island. Unfortunately, the Burke cane was not sufficiently immune to the fungoid diseases then so prevalent in the Island, and as the juice from it required, for its evaporation, fuel beyond that furnished by the megass, it fell into disrepute; and although there are still fields of it to be found dotted here and there, especially in the northern districts of the Island, it has, at the present time, almost dropped out of cultivation. There is a tendency, in some quarters, to adversely criticise the Barbados planters for so suddenly substituting the Burke for the Bourbon to the extent they did in 1894-5. This is, I think, unjustified, for the Bourbon cane was so affected by fungoid diseases that on many estates it was not yielding half a hogshead of sugar to the acre, whilst the Burke, where it was experimentally tried, was not only free from disease but yielded over half a ton of available sugar per acre more than Bourbon when free from fungus. That the Burke cane, under certain conditions, still gives favourable returns may be seen by examining the results obtained at Palmiste Estate, Trinidad, given in Messrs. Hart and Carmody's reports on the sugar-cane experiments in that Colony for 1898 and 1900. During the time the Burke was being tentatively tested on a few estates other canes were also tried, such as Rappoe, Caledonian Queen, Lahaina, Keni-Keni, Queensland Creole, Striped Singapore and Naga B—

a cane supposed to be a sport from the Naga cane. The Lahaina and Keni-Keni soon showed signs of rind and root fungus and consequently their cultivation was discontinued The Rappoe, Caledonian Queen. Queensland Creole, Striped Singapore, Naga B. and White Transparent gave fairly good returns and were almost free from the attacks of fungoid diseases so that their cultivation was continued. The hardy character of these canes also enabled the planters in the drier districts to ratoon- a method of cultivation they had not been able to practice when growing the Bourbon cane.

The next seedling canes of value were the B. 109, B. 147, B. 149, B. 156. In addition to being cultivated at Dodds these canes have been tried on various estates about the Island and with the exception of B. 149 are included in the "Selected seedling series" grown under the auspices of the Imperial Department of Agriculture on certain estates representative of the different districts of the Island. B. 149, although giving fairly good results on a few estates, has not, on the whole, come up to the expectations first formed of it, its cultivation has therefore been practically abandoned. Of the other canes, B. 109, and B. 147 are cultivated on several estates, and have given, in some districts, excellent results, particularly the latter. B 156 has only been tried to a smaller extent, but in the higher districts it is giving promise of being a useful cane.

In addition to the canes mentioned above, there is a seedling cane known as the Sealy or Blackmans' seedling, which is somewhat largely cultivated in the higher parts of the Island with some success. As it appears to be suitable to the soil and climatic conditions which obtain on the red soils, it has been included in the "Selected seedling" plots both at Henley and Blackmans, and is being tested along with the canes under experimental cultivation at those stations.

An effort was lately made by the Agricultural Society, at the suggestion of the Imperial Commissioner of Agriculture, to ascertain the area and yield of the various seedlings and other canes reaped for the crop of 1900. Unfortunately, as yet, no accurate idea can be formed of the quantities and yield of the various sugar-canes at present cultivated, but, so far as I can judge from a statement kindly prepared for me by Mr. G. Laurie Pile covering nearly 4,000 acres of canes for the crop of 1901, and distributed all over the Island, it would appear that the following are the principal varieties now cultivated in the order named: -White Transparent, Rappoe, Caledonian Queen, B. 147, Blackmans' seedling, Naga B, Burke, Bourbon. B. 109, Queensland Creole and Rock Hall cane. The White Transparent is evidently the most widely planted cane at present while the Bourbon has nearly disappeared altogether. B. 147 is planted to a considerable extent on some estates, but comparatively little on others. The total area throughout the Island under this cane, as stated in the President's address, is estimated at about 4,000 acres. The Rock Hall cane, a local variety of unknown origin, is very little planted at present.

Professor CARMODY (Trinidad): During the last twelve months we have induced six estates in Trinidad to undertake similar experiments with seedling canes to those in Barbados. From comparisons already made of the yield of seedling canes in different localities, we are convinced that the only way to test the value of these varieties is by means of experiments carried out on sugar estates by the planters themselves in which the seedlings are grown side by side with other canes under ordinary estate conditions. I hope we shall be able to report much more satisfactory progress than hitherto. Seedling canes have been grown for some time in Trinidad, but in a somewhat erratic manner. Accepting the recommendations made to them, the planters have cultivated seedling canes to a fairly large extent but in one or two cases with disastrous results. Of these failures there are now no published records since, unfortunately, the planters kept the results to themselves. It should be remembered, however, that the results of experiments are of value whether they are unfavourable or otherwise. Now, however, we are proceeding on different lines, as we propose to supervise the year's work and embody the results in our annual report. The present experiments are on a more limited scale than formerly, but I believe they will be of greater value because they will be carried on simultaneously and the results compared and checked at the end of each season. We have already collected and published some very interesting results of experiments carried out on two or three estates by planters who have not received any assistance from official sources. In one experiment, D. 95 was compared with Bourbon and as a result the manager of the estate was convinced that this seedling was as good as the Bourbon. D. 95 has also been under trial on various other estates in different parts of the Island and has given a percentage of sugar above the average. Among the figures obtained, I may mention that at the St. Clair Experiment Station D. 95 gave 14·14 and 16·59 per cent. of sucrose: at Orange Grove Estate 18·97 and 18·15 per cent: at Brechin Castle Estate 17·59 per cent. (first crop) and 17·80 per cent. (ratoons), whilst at Palmiste Estate the result was 15·85 per cent.

In order, however, to have a really satisfactory test of the value of any cane it is necessary to conduct experiments extending over a number of years under various conditions. I would suggest that while these experiments are being extended on sugar estates a great deal more assistance might be given at the Government Experiment Station by raising large quantities of plant canes to meet the requirements of planters.

The PRESIDENT: I might ask Professor Carmody whether the results obtained from the experiments on sugar estates in Trinidad will be controlled and checked by the Official Chemist. I ask this because unless all the canes are tested according to one method and the results brought out in a strictly comparable manner, there may be doubt as to their relative value.

Professor CARMODY: Some Trinidad estates have chemists of their own, but we would provide assistance where there is

no chemist. I am satisfied that the results will be trustworthy and brought out in a perfectly comparable form.

Mr. HART (Trinidad): Up to the present B. 147 has not given the same results in Trinidad as it has in Barbados and the Burke has proved a great failure. The latter cane was tried on some 60 acres at different estates and had to be abandoned because, although it gave a good tonnage, it did not yield sufficient megass and thus proved distinctly inferior to the Bourbon. Consequent on the failure of the Burke, many other seedlings were abandoned. It is evidently a waste of energy for the planters to take up canes that have to be abandoned in a few years. To prevent this I would suggest that the canes should not be sent out from the experiment stations unless they have been under trial for at least five years. If after this period we find that a certain variety is a good cane there will be sufficient guarantee that it is worthy of trial on the estates. Next year our experiments at the St. Clair Central Station will have been conducted for five years and there will be some varieties which have been tested for this period, and every succeeding year other varieties, which have been similarly tested, will be available.

Mr. F. WATTS (Antigua): The experiments which have been conducted in the Leeward Islands have, up to the present in Antigua, been on a very modest scale, but I think it can be claimed that they have proved exceedingly useful to the planters. The experiments have been carried on with the object of combating sugar-cane diseases as much as with the view of finding a better kind of cane; and they were undertaken at a time when the wave of disease swept over the islands and the sugar industry was in such a serious condition as to threaten the credit of the Colony. So great was the alarm that, it was suggested in some quarters that it would be well not to say too much about the matter for fear of the injury that might be done to th. credit of the Colony. Fortunately at that time a small experiment station had been established where a number of canes, chiefly coming from Dodds Experiment Station in Barbados, were being grown and in this station we were soon able to observe that while some canes were badly diseased, others were almost entirely free from rind fungus. The attention of the planters was drawn to this matter with much success, and, from the moment that it was realised that we were able to produce a cane that was not so susceptible to disease, we had to deal with the difficulty, which I see is emphasized by the remarks which have been made by those who have already spoken on this subject, of controlling a desire to rush: as there was a strong wish to plant any cane other than the Bourbon. It is very necessary to make extensive experiments before advising planters what canes should be taken up, and especially is this the case with seedling canes. Planters at first were not inclined to attach much importance to advice based upon laboratory and plot experiments and were apt to select canes which were pleasing to the eye but which, in some cases, did not give good results. Now, however, greater and

increasing reliance is being placed on information based on experiment.

This work of experimenting in the selection of canes has now been put on an entirely new footing by the Imperial Department of Agriculture, and throughout the islands similar experiments are being carried on. Trial plots of selected canes are planted side by side with other canes in the fields. These are looked after by the planters themselves, and are treated throughout their growth similarly to other canes in the same field, and thus planters are able to see how these canes behave and how far they are resistant to disease. The planter has at last recognised that the selecting of what is best is not left entirely to his judgment. This was well illustrated this year in our experiments with the seedling D. 95. While this cane was growing, its appearance in the field was such as to lead planters to suppose that it was of little value, and, for my own part, I expressed the opinion that it did not appear to be of any particular merit. However when we found its comparatively high tonnage on reaping, and discovered that the juice contained nearly 2½ pounds of sugar per gallon, we realised its value. Whether it will retain the position to which it has attained in the Antigua experiments I cannot say, but it will be carefully experimented with and is being planted on a sufficiently large scale to settle this point.

Our experience with another cane shows still more the necessity for caution. We had a cane, the Keni-Keni, which was grown in Barbados and favourably reported on by Prof. Harrison and others. In the first year it came up to expectations, but after that it deteriorated so much that ultimately it was thrown out of cultivation. This goes to show that Mr. Hart's advice with regard to experimenting for five years before distribution to planters for cultivation is one worthy of consideration. It is more necessary in the case of seedling canes than in varieties imported from other parts of the world. I have persistently endeavoured to lay stress on this caution right through our work.

The question of the best method of distribution has been raised. In Antigua we have had experience of several plans. At one time the plants were distributed gratuitously and in a few instances were little valued. We then suggested selling the plants at some fixed price and finally we decided to sell them by auction, a plan which has answered admirably. If a planter wants certain varieties of canes he pays for them, if he does not want them he does not buy them. Thus we have an idea what canes are in great demand and have some measure of the importance attached to them by the prices paid. When this plan of sale by auction was introduced it was gratifying to find that the canes fetched prices in proportion to the degree of merit attached to them in our reports. I would suggest that the other experiment stations in the smaller islands might, with advantage, try this plan of selling by auction.

The results of experiments made during the past year' which we have just put forward from Antigua, and which are already in the hands of some members of this Con-

ference must be judged by comparison with the sugar output from the Island for the year under discussion. It must be remembered that in this season the output was less than half the average, so that under these circumstances I think we can regard the yields of some of the varieties experimented with as highly satisfactory.

At St. Kitts the work is entirely new and we shall reap the first crop of canes from the out-stations during the coming season. But I may say that, owing to the spread of rind fungus, a keen interest is taken in the work by the planters in this Island, and the canes under experiment are being closely watched. The plots are not in the most satisfactory condition since this was the first year of the work and there was nothing to fall back upon to supply the gaps caused by canes which failed to grow. However, I think we shall see in St. Kitts, as in Antigua, that the Island will be planted with those canes which are recommended as the result of the Experiment Station work, and as the experiments proceed the planters will recognise this work as being of the greatest importance to them.

At the present moment there is some tendency on the part of anxious planters to plant any new cane, but, as the result does not always prove successful, they are beginning to realise the fact that it is better to be guided in their selection by the results obtained at the experiment stations, and to have these particular varieties, which can be recommended, supplied to them from the stations. In the Leeward Islands, I am glad to say that owing to the interest taken by the planters there is no difficulty in getting what we want done. They are willing to afford us every reasonable assistance, so that I have not the slightest doubt that, as time goes on, we shall be able to put the matter on a sound footing and that permanent good will result.

Mr. Fawcett (Jamaica): I congratulate Professor d'Albuquerque and Mr. Bovell on their work on seedling and other canes and the Imperial Department of Agriculture on the very convenient form in which the results are presented to sugar planters in the pamphlet before us: "Seedling and other canes at Barbados, 1900." Instead of having to wade through long tables of figures we have here a condensed summary which is most useful. I am somewhat disappointed that the seedling D. 95 has not been included, but I presume the reason is that it has not been as successful in Barbados as other seedlings have been. In Jamaica it has been found so successful under certain conditions that two planters have informed me that it has yielded twice as much sugar as the White Transparent. The conditions referred to are an alluvial soil near the sea.

The principle that planters should themselves experiment with various varieties on their own estates under similar conditions to those under which other canes are cultivated is the one that has been adopted in Jamaica before and since the time when the President was there as Director of the Public Gardens. It is a principle which has been most successful, since planters have been able to substitute any cane which proved itself useful in that particular spot for those previously culti-

vated. I believe our freedom in Jamaica from fungoid diseases is largely due to the selection of healthy tops and the substitution of one variety of cane for another. In the Cane Valley district, the only place in Jamaica where the fungus did any real damage, the planters got rid of it completely by substituting for the Bourbon cane the White Transparent which was brought from another district. Occasionally the fungus reappeared to a slight extent and in every case it was found that a diseased stool of Bourbon had been overlooked.

Now that we have a chemist, Mr. Cousins, whose work will be chiefly agricultural, we hope that more organised work will be undertaken than has been found possible hitherto.

Professor Carmody has referred to a wish on the part of the planters to be able to get large quantities of any particular cane from the Botanic Gardens and Mr Hart has answered him by pointing out the great disappointment which followed from the planting out of 60 acres of the Burke cane before it had been properly tested. It would be difficult, on account of the limited space at our disposal, to have a large acreage planted out in different varieties at the Jamaica Botanic Gardens. The more convenient plan would be for planters themselves to start with properly tested varieties and then gradually extend the cultivation as found desirable.

Mr. Sharp (Jamaica): I take it that although some varieties of cane may be recommended generally, yet the conditions under which they must be grown will decide the question whether or not they are the best for a particular estate. In Jamaica the amount of fodder yielded by the cane tops is a point of great importance since in several large districts we feed the stock largely on cane tops. Again, on account of the high price obtained for Jamaica rum from its particular flavour, planters should proceed cautiously in cultivating new varieties lest they grow a cane which may injuriously affect the quality of the rum. I should like to know if the wisest plan would be to introduce into Jamaica as many good varieties as can be obtained and then induce the sugar planter himself to experiment with these on his own estate so as to find out the variety best suited to his soil. I know that D. 95 has given great satisfaction in several localites but I think it would be going too far to say that it has given satisfaction throughout the Island.

Mr. Hudson (St. Lucia): B. 147 has given good results as a plant cane in St. Lucia at the Cul de Sac Estate, but not as a ratoon. In consequence B. 147 is being given up on this estate in favour of the Bourbon, since the latter ratoons for several years in rich bottom lands.

Mr. F. R. Shepherd (Antigua): I should like to mention that D. 95 has given excellent results in Antigua without the application of artificial manure. B. 147 has also given similar results in some localities but contrary to experience at St. Lucia it has proved our best ratooning cane in experiments, for instance, at Bendal's estate.

Mr. Bovell (Barbados): I should like to add that D. 95

has been tried in Barbados for some years but the results were not very satisfactory. We propose however to include it in the list of seedling canes to be investigated for the crop of 1902.

THE PRESIDENT: - The point raised by Mr Sharp with regard to the yield of fodder by certain varieties of canes is fully dealt with in the pamphlet on "Seedling and other canes at Barbados, 1900." In the tables at the end the weight of canes and tops per acre are given in each case. The other matters referred to will, I am sure, receive careful consideration from Mr. Fawcett and Mr. Cousins, and the Jamaica planters will be advised what to do. In regard to experience on one estate at St. Lucia with B. 147 cane, what Mr. Hudson on the one hand, and Mr. Shepherd on the other, have laid before us, only confirms what has already been very clearly laid down by the Department of Agriculture: that it is hopeless to expect any one variety of cane to suit all conditions in the West Indies. D. 95 does well on some estates in British Guiana, but is useless on others. At Barbados it was discarded some time ago but is being retried on a small scale this year. At Antigua it seems to be the most promising of any of the new canes in that island. At Jamaica, as Mr. Sharp has informed us, it suits some estates but is not successful in the higher and moister districts of the island. The problem before us, it seems to me, is to work out by patient and reliable experiment over a number of years the characteristics of various canes, and recommend only those that after exhaustive trial are suitable to each locality. To attempt to force the cultivation of one variety under all circumstances cannot but end in failure.

In the matter of experiment stations started on sugar estates in typical districts it would seem to be overlooked that unless the results are worked out under the supervision of the Official Chemist in each case, it will be impossible to include them in the general results for those Colonies. These local experiment stations should be regularly visited by both the Official Agricultural and Chemical Officers in charge, and the growth and habit of the canes and the general treatment carefully noted. Before being cut, they should be tested beforehand to see whether they are ripe, and the subsequent selection of samples and working out of the results carried out with great care. It would be preferable not to start these stations at all than to carry out the work in an incomplete manner.

CANE-FARMING IN TRINIDAD.*

BY PROFESSOR P. CARMODY, F.I.C., F.C.S.

Government Analyst, Trinidad.

In this Island, until recent years, sugar was manufactured exclusively from canes grown by the owners of the factories. The chief drawback to this system was that, in bad seasons, the losses fell almost entirely on the comparatively few owners, and made such heavy demands on capital that many factories had to be closed, and the estates abandoned so far as sugar production was concerned. These factories might have survived under a judicious system of cane-farming.

About six years ago, there was distinct evidence of a departure from this long established practice: and a large quantity of canes were grown by cane-farmers and sold to the factories at a fixed price. The following table, prepared chiefly from returns published by the Agricultural Society, will give some idea of the growth and present dimensions of this industry.

Year.	Total Sugar production.	Estate grown canes.	CANE-FARMERS. Canes.	Price Paid.	Number and Nationality. E. Indians	W. Indians
	Tons.	Tons.	Tons.	Dols.		
1895	55,000		35,000	.	..	..
1896	59,000		75,000		3,744	
1897	55,000					...
1898	58,000		105,000	203,000	2,326	3,824
1899	58,800	420,000	106,000	219,000	2,826	3,870
1900	46,000	361,000	106,000	228,000	2,826	3,591

*This subject is very fully dealt with in the Report of the West India Royal Commission, Appendix C. Vol. II p. 309, 317 et seq. The Memorandum prepared by the Hon'ble Rene de Verteuil, President of the Cane Farmers' Association of Trinidad is especially worthy of perusal by those interested in cane farming. There are also interesting statistics referring to the subject. The following observations on cane-farming appear in the body of the Royal Commissioner's Report (p. 30): –

"It is recognised in the present day that the business of manufacturing sugar may often with advantage be separated from the actual cultivation of the canes. It is found convenient in many places that farmers should engage in the business of growing canes, and should sell the ripe cane to a Central Factory. This system is being tried, and with some success, in Trinidad though a strong, and apparently well-founded opinion has been expressed to the effect that, so far as can now be seen, the Central Factories in Trinidad can never depend entirely on canes so grown, but must, in order to ensure a continuous supply of canes for manufacture, possess a considerable amount of cultivation of their own. It was alleged that the presence of indenture

It will be seen that although there is no increase in the Colony's production of sugar, yet the cane-farmers now produce between one-fourth and one-fifth of the total supply of canes. It has become, therefore, in the short space of a few years, an important contributory branch of the sugar industry of this Island, and, as such, its present position and future possible developements require careful consideration from all who desire to see the cane sugar industry maintained.

The remarkable progress of cane-farming in Trinidad is due (1) to the fostering care of the Agricultural Society, which, at an early stage placed the cane-farming industry on a working basis as stable and definite as if it had been legalised, (2) to the ready sympathy and support of the factory owners, and (3) to the easy and practically irresponsible terms on which, owing to the scarcity of labour, land could be obtained for cultivation. The first meeting for the purpose of reporting on the best means of promoting and encouraging the cane-farming industry was convened by the Agricultural Society in 1895, and the following report was presented by a Committee representing both cane-farmers and estate owners.

1. "The Committee are of opinion that freedom of contract should not be interfered with, but that a sliding scale for the price of canes by weight according to the price of sugar should be established by law, which, in the absence of any specific agreement under the Agricultural Contract Ordinance or otherwise, should determine the price to be paid.

2. The sliding scale should be based on the calculation of fifteen tons of canes to the ton of muscovado sugar and the Committee consider that at 10/- per cwt. a ton of muscovado sugar is worth £8 net value.

3.- (a) I. That at the present price of sugar six shillings per ton for standing canes or nine shillings at the factory is the highest rate estates can possibly be expected to pay for farmers' canes, and that rate can only be paid with a view to fostering the industry, as it involves in many or most cases an actual loss.

(b) II. The Committee are of opinion that the above price is necessary at present to encourage the cane-farming industry, but that no increase in price should take place until muscovado sugar is quoted in England at 12/- per cwt.

4. The following sliding scale is recommended by the Committee for adoption:- When muscovado sugar is quoted in

coolies is essential to the maintenance of the industry, as only in this way could a reliable supply of labour be secured at all times.

The owners of sugar estates in Trinidad appear to be fully alive to the advantages of the cane-farming system, and anxious to introduce it as far as practicable. The general adoption of the system would be attended with many advantages, and we are of opinion that it is one which the Government might legitimately assist, where practicable, by providing means of communication to facilitate cane-farming in suitable localities. Both the Creoles and the East India immigrants prefer growing canes on their own plots to working as labourers on the estates, and they are willing to sell their canes at a price which is below the cost at which the estates can produce them."

[ED. W.I.B.]

England above 12/- per cwt. the price of canes per ton in the field to be one half the price quoted in England of sugar per cwt. with three shillings additional for cartage to the factory.

5. The Committee recommend that while sugar is at the present low price and until it reaches 12/- per cwt. for muscovado the freight for haulage per Trinidad Government Railway be reduced to the lowest possible price; they recommend this strongly as one means of encouraging the "cane farming industry."

The following facts were elicited from two cane-farmers who have been and are growing canes for "Woodford Lodge Factory":

Cane-Farmer Stewart stated that he had expended $228.00, including the value of his own labour at 30c per day on ten acres of land. In 1893, from August to December, he planted five acres of canes and with them, while young, grew potatos which realized $55.00 in December. In 1894 he planted five acres in canes for the crop of 1896, on which he had expended $50.00. This sum is included in the $228.00. From the five acres planted in 1893 he will reap 180 tons of canes, which at 6/- per ton will realise $259.20. His account therefore stands thus:

Dr.		Cr.	
Expended, including his labour at 30c. ℔ day	$228.00	Potatos	$ 55.00
		Spent on Canes for crop 1896	50.00
Profit on crop 1895	136.20	180 tons Canes at $1.44	259.20
	$364.20		$364.20

He will have for crop 1896 five acres of plant canes and five of first ratoons.

Cane-Farmer Taylor has reaped five acres and has employed labourers himself and paid them, as he works as a drainerman. He realised very nearly 35 tons of cane per acre, and made a net profit of $108.44 after paying all expenses of labour, etc. and states that he has now taken an additional 11 acres, making 16 acres in all that he is now working under contract.

The Committee consider the statements of these two cane-farmers are of importance, for they conclusively prove that the minimum price of 6/- per ton for standing canes leaves a considerable margin of profit to the industrious cane-farmer, and the Committee express the hope that the publication of what has been effected by these men will have a beneficial effect on those who are now engaged in cane-farming, and be an incentive to others to adopt it.

It is clearly established that "farmer-grown canes" produce the cheapest sugar made at the several factories and therefore the Committee most strongly urge on buyers of the canes the necessity that exists for extending liberal treatment to this class of growers, by helping them from time to time with

small advances of money as soon as the canes provide adequate security for such advances.

Cane-farmers are divided into three classes:

I. Those who grow canes on their own lands.
II. Those who do so on lands rented.
III. Those who do so on lands belonging to factory holders.

The first class are those who will naturally sell to the highest bidder, and consequently competition on the part of buyers and the law of supply and demand will regulate the prices they will obtain. To this class a sliding scale will be of great value. The foregoing remarks apply also more or less to the tenant class, except in those cases where the landlord may make special arrangements for payment of rent.

The farmers of the third class will as a matter of necessity produce their canes under specific agreements equally binding on both contracting parties. Fair treatment on both sides is necessary for establishing that confidence which will be productive of gain to growers and buyers.

At the present time, cane-farming is in a very limited sense an adjunct to the sugar production of the Colony but the Committee see no reason why under such conditions as recommended in their report cane-farming should not assume large dimensions and become an important factor in securing prosperity to the sugar industry of Trinidad, and what is perhaps of even more importance be the means of inculcating habits of thrift and industry which are now lamentably absent in our agricultural classes.

The Committee cannot conclude their report without thanking Messrs. Warner, Sanderson, and de Verteuil for attending this meeting, and for the valuable information they afforded."

This report outlined the conditions on which cane-farming should succeed; and, although no sliding scale has been adopted by law as suggested, these crude conditions have on the whole been faithfully observed. They must have proved fairly satisfactory to those immediately concerned, for they have stood the test of five years' experience without substantial alteration and almost without complaint. We do not find any further important reference made by the Agricultural Society to the conditions of cane-farming until 1899 when the following report of the Cane-farming Legislation Committee was published.

1. "In considering ways and means of encouraging and firmly establishing cane-farming as a sound industry, we are confronted at the outset by two main difficulties which we think must be overcome before stability can be given to that industry.

2. These difficulties are: -

(*a*) The settlement of all questions arising between owner and farmer without recourse to the Supreme Court which entails costs out of proportion to the subject matter in dispute:—*e.g.*, on Friday, 3rd November, in

Grant v. Greig, the judge awarded a farmer 15/- with £4 costs, against Greig.

(b) Advances to farmers for cultivation purposes and security for their repayment.

3. An Ordinance on the lines of the third "Agricultural Contracts Ordinance 1899," would, to a great extent and with some modification, meet the situation.

4. In such Ordinance the term "cultivate" and "cultivation" must be clearly defined in order that Magistrates might with certainty act in cases where it is sought to eject a farmer for improperly working his land. A tenant farmer, paying rent for land, should be included when he contracts to plant, and, as in the 1899 Ordinance, the forms of contract can be given, and their registration provided for.

5. As regards advances on loan to farmers for agricultural purposes and the security for repayment, a memorandum of loan in writing should be registered in the office of the Magistrate in which the contract was made, and such advance on loan should, when so registered, become a charge against the value of the crop when realised and (subject to payments of rent) should give preference to the registered holder. These documents should be open to inspection at all reasonable hours upon payment of a small fee.

6. The jurisdiction of the Magistrate should be extended to £100 with power to try questions of law and fact. In cases where it is sought to cancel a contract under the proposed Ordinance, notice should be given by the plaintiff to the registered holders of Memos. affecting such contracts, and if any money payment is ordered, the Magistrate should have power to order the payment thereof to such registered holder of a Memo. of advance, or with the consent of the owner and on the application of the registered holder, order the transfer of such contract to such registered holder.

7. We think that legislation on the above lines would encourage cane-farming, and the individual farmer would in all likelihood engage in contracts on a much larger scale than exists at present. The feeling of security that would follow would doubtless lead to pecuniary aid being given to the honest farmer and without such security, local or village banks can hardly be brought into existence."

This indicates some of the drawbacks of the cane-farming system as carried out in Trinidad which already call for remedy. These are by no means the only ones, and our cane-farmers have, I think, every reason to be grateful for the benevolence of factory owners in renting lands under present conditions.

The majority of Trinidad cane-farmers start without land, capital, or responsibility, and without any permanent interest in the cultivation they undertake. They cannot even provide labour without a suitable system of advances. From the estate owners they get the use of the land free, or rent it for a nominal amount, and very often the advances above referred to. No new lands are brought into cul-

tivation by the cane-farmers. They will grow canes as long as their plots yield them, and will then pass on to an unexhausted plot. The use of manures, either artificial or pen, is not a condition which it has been found practicable to enforce; and yet this condition is the most essential in any system in which the cultivator has no permanent interest in the land. The cane-farming cultivation, as carried on at present, cannot fail to increase the large areas of exhausted lands; and this must have a very prejudicial effect on the future of the sugar industry. The low price of 6/- a ton is misleading the real price is 6/- plus the capital in the unexhausted plots belonging to the estate owner. This is by no means the only loss the latter suffers. It costs him more to grow his own canes than before, because his labour supply is diminished and it costs him more than before to manufacture his sugar, because the canes are of inferior quality, and, because, for want of organisation, he cannot rely from day to day on a constant supply of farmers' canes.

According to cane-farmer Stewart's experience, a ton of plant canes costs him $1 for labour only. No charges for rent or manure are mentioned. But he has grown 36 tons of canes per acre which at 6 - realise £10. 16. 0. giving an apparent net profit of £3. 12 0 per acre which would be a very satisfactory return if no further deductions were to be made His expenses for two successive ratoon crops should be less than for plant canes. On the whole, an industrious cane farmer should find cultivation under these conditions profitable. If he cultivated 100 acres on the same conditions, instead of only 5 or 10 acres, his annual profit would exceed £300 a substantial income for a man of the class to which cane-farmers belong. If this be the experience of other farmers, it is not to be wondered at that cane-farming has made such rapid progress in Trinidad; and it is a matter of surprise that some of our educated and intelligent young Creoles who are still crowding into the already overstocked medical and legal professions have not devoted their energies to an industry which requires so little capital and skill, and brings so quick a return. It would be an excellent initial training for them in agricultural pursuits; they would gain a practical knowledge of the soil and the management of labour; and, if they have aptitude for the work on a large scale, they would earn within two years a fairly good income. They could raise cane farming above its present industrial level which is, I regret to say, in danger of sinking.

The ideal cane-farmer is, in my opinion, one who works his own land, or has something more than an annual interest in it; who carries on his operations on a sufficiently large scale, or cooperates to employ draft cattle for the three-fold purpose of carting his canes to the mill, of ploughing the land, and of producing pen manure; and who undertakes to arrange to deliver his canes in regular daily quantities. The bulk of the cane-farmers do not at present reach this ideal. But many of them are, or could be made, good cane-farmers, especially those who work regularly on the estates and cultivate canes in their spare hours, or with the assistance of their families. The only draw-

backs to this class of farmer are that he exhausts the soil through having no manure of his own to apply, or being too poor to purchase any and that he is unable to co-operate with his brother farmers for the regular delivery of canes to the mill.

This irregularity is well shown by the following figures representing tons of farmers' canes delivered on consecutive days at one factory:

April	28	. 110 tons	Feb.	24 ..	92 tons	March	28	. 193 tons
„	29	5 „		25	161 „	„	29	.. 326 „
„	30	161 „		26	315	„	30	195 „

At the risk of repetition I cannot avoid pointing out that the question of manuring is a most important one to the cane-farming industry, and that in other countries it is very unusual I might say unknown to rent land to farmers except for root crops which could not be grown without the use of manure. In Trinidad, an estate owner rents lands for cane cultivation for at least three years, by which time the farmer may have thoroughly exhausted it. The following figures are from actual results:

Farmer X. (13 acres).

Plant canes	81 tons	6	tons per acre	
1st Ratoons	230 „	18	„ „	(including standovers)
2nd „	152 „	- 11	„ „	
		35		
Average per year -		11·7	„ „	

Farmer Y. (7 acres).

Plant canes .. .	18 tons -	5·5	tons per acre
1st Ratoons	72 „	10	„ „
2nd Ratoons (2 acres)	15 „	7·5	„ „
		24	
Average per year —		8	„ „

These results are considerably below the average yield of the estate cultivation in the same district, and show that no attempt has been made to realise the average possible return. The plots have evidently been allowed to yield what they could without assistance in the form of cultivation or manure, and with the inevitable result exhaustion. Unless some condition is made that the yield of canes per acre from farmer's cultivation does not fall materially below the estate yield, working under similar conditions, it is not too much to say that the agricultural prospects of the sugar industry are not in a satisfactory position, and that future troubles are in store for it.

From the sugar manufacturer's point of view, nothing could be more advantageous than to buy all his canes at a fixed price if he could rely on a regular and sufficient supply. He cannot do so at present. Buying 15 tons of canes for £6. 15. 0, and selling the ton of sugar produced at £12, leaves a margin of profit after deducting cost of manufacture, freight, etc. Bought

canes would relieve him to a great extent of the present troublesome labour question, and of many other anxieties. The serious crises in the sugar industry are chiefly due to losses in the cultivation, and only to a comparatively small extent in the manufacture. The cost of cultivation is generally the same whether the year is a good or bad one; and in a bad year, the losses arising from a diminished yield of sugar fall with crushing severity on the unfortunate owner of a large estate. For economic reasons, the mill owner must always remain a cane grower; but it is a question whether at present he does not attempt to cultivate more acres than his labour supply can satisfactorily accomplish. If, without diminishing his own supply of labour, he could get relieved of some of this cultivation by industrious cane-farmers who understand the advantages of good tillage, rational manuring, and industrial co-operation, the sugar industry would prosper.

The Imperial Department of Agriculture is in a favourable position to collect information respecting the conditions on which cane farming is carried on in other West Indian Colonies; and as I believe that great advantages to the sugar industry would be derived from a properly worked system of cane-farming, I suggest that it would be profitable to publish this information for the guidance of all the Colonies, giving special attention to the questions of (1) manuring, (2) co-operation in the delivery of canes at the factory, and (3) money advances to farmers at a moderate rate of interest.

DISCUSSION.

Mr. F. WATTS (Antigua): In Antigua, attempts have been made to establish cane-farming, but, so far, without success. In many instances men have made it pay but they have then usually abandoned the industry and invested their savings elsewhere. I should like to know whether the success attained at Trinidad is due to the greater persistency of the East Indian as compared with the West Indian.

Professor CARMODY: I am glad to say that the greater number of those engaged in cane-farming in Trinidad are West Indians. The system originated, when some of the smaller estates dropped out of sugar cultivation and were being abandoned. Thereupon several of the better class men, artisans and others employed on the estates, adopted this method. Since then it has been taken up by East Indians, but the West Indians are still in a majority.

Mr. G. S. HUDSON (St. Lucia): Cane-farming in St. Lucia originated with the establishment of Central Factories. Of late years it is declining in popularity. The industry is principally in the hands of those proprietors who own land near Central Factories. The usual price paid for canes is 10s. per ton delivered on the factory's railroad, the grower providing cattle and waggons. At one factory, artificial manure

is supplied to the cane-farmers, and its cost deducted from the price paid for the canes.

MR. A. J. JORDAN (Montserrat): In Montserrat, a large amount of cane cultivation is carried on under the 'metayer' system. The cultivators grow their canes on estate lands and deliver them at the mill for one-half their value, receiving an additional amount for their assistance in grinding. The same difficulty has arisen here, with regard to cultivation, as in Trinidad. The cultivators have no permanent interest in the land and so merely obtain from it as much as possible, giving little or nothing in return. Many have indeed told me that should they increase the value of their lands by careful cultivation or manuring, the proprietor would in all probability take it from them. If it were possible to give the people an interest in the land by which it would become their own property in time, the condition of the cane-farming industry in Montserrat would soon be much improved.

INSECT PESTS OF SUGAR-CANE.

BY H. MAXWELL-LEFROY, B.A., F.E.S.

Entomologist to the Imperial Department of Agriculture for the West Indies.

The most destructive insect pest of the sugar-cane at the present time is, as you are aware, the moth borer. This has been dealt with in a pamphlet issued last year and at greater length in an article in the last number of the West Indian Bulletin. You are doubtless acquainted with the recommendations already made and I wish to take advantage of this opportunity to emphasize certain points dealt with in that article and to say a few words about other pests.

The moth borer is very plentiful in Barbados, Antigua and St. Kitts, attacking cane, Indian corn, Guinea corn, and sorghum. There can be no doubt that at the present time it is responsible for a very considerable amount of damage to sugar-cane, either directly, or indirectly through the rind fungus. Apparently this damage is to a large extent ignored, being accepted perhaps as part of the regular order of things. It is difficult otherwise to understand why so little is done in many cases, and I think it will be admitted that a considerable amount of sugar is needlessly lost every year owing to the lack of vigorous efforts to combat the pest. So far as Barbados is concerned there appears to be sufficient evidence to justify the statement that vigorous measures to destroy the moth borer would not only produce an increased yield of sugar but would also cost practically nothing. The increased yield of sugar in the first crop would amply pay for the cost of the remedial measures, and there would be a permanently increased yield

after three seasons careful destruction of moth borer. It is to be hoped that during the coming season some efforts will be made in this direction. The remedies proposed were selected on account of the fact that they seemed to combine directness, efficacy and small cost in the greatest degree. Collecting the eggs was adopted to some extent in Barbados and in St. Kitts during the past year, and so far as I was able to observe no remedy is so simple to carry out or requires less labour. Children can collect the eggs very well, and this ensures the destruction of the pest before it has been able to do any damage. The most favourable time is during the five weeks at the end of the reaping period and the week after, since during the time the crop is being cut, the moths are migrating to the young canes. As the old crop diminishes the number of moths in the young canes and the number of eggs laid there increase, and when the last cane is cut, all must be in the young crop. If the egg collecting i carried out during this time, the maximum effect is obtained, and if it were possible to collect every egg, it is hard to see how any moth borer could escape. I believe this to be so successful a method that three seasons' work, throughout Barbados, would see the moth borer practically exterminated.

There is nothing to add with regard to the cutting out of dead-hearts. It too has been shown by experience to be a direct and practical remedy, easy in application and fairly beneficial in results. The use of lights has now a new interest. During my visit to Antigua, some experiments were carried out by Mr. F. R. Shepherd at Skerretts, in which trays of molasses or kerosine were used with and without lights, to trap the moth borer. The trays containing molasses caught a fair number of insects, including some moth borers, but by far the larger number were caught in the trays where they were no lights. The molasses in both cases was the attraction, but the light seems to have been the reverse of an attraction. Where kerosine was used a few insects were caught when there were lights, but none where there were no lights. So the lights in this case appeared to attract a few insects. It is not yet clear to what extent this holds good for the moth borer itself and a larger series of experiments will be carried out, as soon as possible, to settle this question. If trays of molasses can be used without lights, the remedy will be still cheaper in application. The value of this remedy is due to the fact that it can be used when the canes are too tall for egg collecting or the destruction of dead-hearts, and because the expense is slight. In Antigua and St. Kitts serviceable lamps are constructed at a cost of a few pence.

It is claimed for the above three remedies that they have a threefold advantage over others: they are easier to carry out, they cost far less, and they aim directly at the destruction of the pest. If the experience of this season shows that they have also the merit of efficacy, it is to be hoped they will be adopted more widely. But until they are tried more extensively by those who grow sugar-cane, there will be no experience to guide us in the future. and the practical eradication of the moth borer will be as far off as ever. In this connection, the

question of united action could be usefully discussed. The spread of moth borer from an infested estate to neighbouring estates will probably prove to be a slow process. The weak powers of flight of the moth do not allow it to travel far, nor would there seem to be any necessity for such power. If measures to destroy the moth borer are adopted by one planter, there is no doubt that he will benefit and that the failure of his neighbours to act with him will not neutralise his efforts to any great extent. But, if moth borer is to be entirely destroyed, this very desirable result will be secured only by the co-operation of all. When it is recognised that there are suitable remedies for moth borer and that the adoption of these as part of the regular estate work will be a benefit, it is to be hoped that the planters will, in the interests of all, demand united action. I should have no hesitation in strongly recommending such a course at the present time, as one likely to produce good results in Barbados, and though I have less information concerning St. Kitts and Antigua, it is probable that it might very usefully be considered in those islands also.

There are two other pests of sugar-cane that deserve notice.

An insect known as the ladybird borer, *Sphenophorus sacchari*, has been the subject of writings by C. A. Barber and others. This insect was wrongly named. It is really *Sphenophorus sericeus*, occurring in Jamaica, as well as in Barbados, St. Kitts, Antigua, St. Lucia, British Guiana and probably also in Trinidad. The grub feeds in the cane, destroying all but the rind. It then makes a fibrous cocoon and emerges as a brown and black weevil. It is not as yet certain whether this insect can be classed as a direct parasite or not. I have found it in the stumps of ratoon canes, in canes that have been planted, and in broken canes in the field, and it is probable that this insect cannot penetrate a sound growing cane but enters at cut or broken surfaces. Should this be the case, little damage is likely to result from its attacks, but it is at present abundant and should be checked. This can be done by destroying all infested canes and by catching the mature insect in trays of molasses. Large numbers can be caught in this way if a tray of molasses is used with a light.

The cane-fly, *Delphax saccharivora*, has been seen in Barbados and Antigua. An interesting case occurred recently in Barbados. The canes on one estate were reported to be full of cane-fly and a visit to the spot showed that the fields were literally full of it. On shaking a cane a cloud of these insects would fly out and hundreds could be seen on one leaf. This estate had not been visited during the preceding two months, but in the early part of the year I was constantly among the canes and saw very little *Delphax*. It must have increased enormously during August and September and in October I saw the fields badly infested for the first time. The canes at the wind-swept edges were free from the pest and, as an experiment, trash was stripped from the canes in part of one field to let in the wind. This made no appreciable difference to their numbers. Their natural enemies increased slowly, being mostly ladybird beetles *(Coccinellidae)* and the larvae of the " golden

eye" or lacewing fly *(Chrysopa)*. There was no diminution in the numbers of the pest towards the end of November, but on my return from Grenada in December I visited the estate and was surprised to see that it had entirely disappeared. There were abundant traces of its recent presence but I was unable to find a single insect. Possibly its natural enemies had been too much for it, at any rate its very sudden disappearance was most remarkable. The presence of *Delphax* is shown by the black blight, which is a fungus living on the sweet secretion which falls from the *Delphax*. In spite of the enormous numbers of this pest, little injury seems to have been done to the canes and it is doubtful to what extent it can be a serious pest.

This closes my remarks on the injurious insects attacking the cane. There are several other pests, and several saprophytic organisms, but they are of very minor importance. Other insects are recorded from Jamaica, Trinidad and British Guiana but I have no information as to their present importance. So far as I am able to see there does not seem to be any reason why a single ton of sugar should be lost owing to the attacks of insects, if vigorous efforts were made to destroy them. Few pests are so easy to deal with as the moth borer, yet few are allowed to work such havoc unmolested as this insect does in the West Indies at the present day.

DISCUSSION.

Mr. F. WATTS (Antigua): I am extremely grateful to Mr. Lefroy for the way in which he has investigated the life-history and treatment of the moth borer. I am glad he has also drawn attention to the weevil or ladybird borer. I am under the impression that this particular borer has been overlooked in our discussions on the injurious pests of the sugar-cane. Mr. Lefroy suggests that this insect does not act as a direct parasite but only gets into injured canes. The conditions under which I have seen this weevil and its larvæ would render that idea somewhat problematical. At any rate I hope Mr. Lefroy will work out the life-history of the weevil borer in as thorough a manner as he has worked out that of the moth borer. I have made some experiments on this subject, but the results are not complete enough for publication. As far as I can ascertain, the mature insect spends the whole of its time underground during the day, coming to the surface about four o'clock in the afternoon. What it does in the night I am unable to say. The subject is one to be left to Mr. Lefroy. If he can tell us what it does then perhaps we shall be able to tackle the question as to how it should be treated with a view to its eradication.

Mr. F. J. CLARKE (Barbados): It seems to me that planters would be criminal to neglect the very simple and easy means which Mr. Lefroy has told us would rid us of these pests of our sugar-cane fields. As a practical planter I have tried the

collection of eggs, but the conclusion I have arrived at is that where we have a large area of thickly growing canes to deal with, this remedy appears difficult if not impossible. It would be doing us a service if Dr. Morris would allow Mr. Lefroy to visit certain parts of the island and show us how the planter could carry out the egg-collecting in a practical way.

Mr. F. R. SHEPHERD (Antigua): I instituted regular and systematic work on the basis of Mr. Lefroy's report in my neighbourhood in Antigua, in a field of eight acres, four acres of these only being under my direct supervision. I sent out the Reformatory boys to collect the eggs. The field contained about 2,200 stools to the acre, and from 10 to 12 canes in each stool. A large number of eggs were collected and brought to me daily which I examined and found to be eggs of the moth borer. I am satisfied that the method is a good one and I feel sure that this year we shall see good results from it. With regard to the placing of lights in trays of molasses I can confirm what Mr. Lefroy says. The moth borer is not attracted by lights and can easily be caught by molasses alone. In fact the lights tend rather to keep them away than to attract them.

Mr. BUNDY (St. Lucia): How many hours a day do the collecting gangs work?

Mr. LEFROY: In reply to Mr. Clarke, I may say that egg-collecting is found to be a thoroughly practical remedy. In my own case I found I could collect the eggs at the rate of two acres of canes per ten hours. I was fortunately able to make observations on the work done on some estates in Barbados. I found that one girl could collect the eggs of 3,000 cane-holes per day. One may safely reckon one and a half acres of canes as a day's work for each member of a gang of girls, giving a rate of 9 acres per week. A small calculation (simply dividing nine into the total acreage under young canes) gives the number of girls in a gang that could deal with all the young canes on an estate within a week. I searched the canes after a gang had been through and in no case was I able to find any eggs left on the leaves. The gang must be large enough to examine all the canes every week beginning every Monday at the point where they started the previous Monday.

In reply to Mr. Bundy the gangs work about ten hours a day.

THE PRESIDENT: I hope that next year we shall be in a position to give the actual results of experiments in egg-collecting in this and other islands. Mr. Lefroy has already visited estates in Barbados, Antigua and St. Kitts and given assistance in starting the collecting of eggs. I hope it may be possible for him to visit other localities during the next few months. This matter of egg-collecting, it must be remembered, does not stand alone. It is intimately connected with the distribution of the rind and root fungus. I believe the less borer we have the less fungus will be present in the canes. With regard to fungus, Mr. Albert Howard has been good enough to prepare notes on the fungoid diseases of the sugar-cane which he will now present to the Conference.

FUNGOID DISEASES OF SUGAR-CANE.

BY ALBERT HOWARD, B.A., A.R.C.S., F.C.S.

Acting-Mycologist and Agricultural Lecturer to the Imperial Department of Agriculture for the West Indies.

Notwithstanding the fact that much has been written and that some experimental work has been done on the diseases of West Indian cultivated plants in which parasitic fungi play the principal part, nevertheless very few people have a fair conception of what a fungus is and in what manner it may cause the destruction of entire crops. It appears, therefore, desirable to indicate very briefly the place occupied by the fungi in the vegetable kingdom, how they live and cause disease, and how they contrive to tide over what is to them an unfavourable period.

Besides the flowering plants we find in Nature a much larger division known as the flowerless or spore-bearing plants of which ferns, mosses and sea-weeds are every-day examples. The fungi, of which there are some 10,000 species, belong to the flowerless plants and are characterised by the entire absence of green colouring matter. Consequently, they cannot utilise the energy of sunlight and are driven to obtain their food in the form of complex organic matter which has been built up from simple substances by green plants. Those fungi which obtain their nourishment from dead organic matter are known as saprophytes, while those which live entirely on living plants or animals are known as parasites. Between these extremes there is a very large group, which becomes greater as investigation proceeds, which are partly parasitic and partly saprophytic according to conditions. To this intermediate class, which includes forms exhibiting every gradation between almost complete parasitism and almost complete saprophytism the rind fungus of the sugar-cane belongs. Recent researches have shown that saprophytes like the common blue mould will become parasitic on living plants if the tissues of the host have been injected with a two per cent. solution of cane sugar. This is a fact of some significance and probably explains why the inroads of the rind fungus become so rapid when the canes are ripe.

While a few of the fungi, among which may be mentioned mushrooms, toadstools and the bracket-shaped bodies seen on old wood, are of comparatively large size, by far the majority of the group are so small that powerful microscopes are necessary for their study. This is probably the reason why such erroneous ideas exist with regard to them and their work. It is not uncommon to find people in England who regard them as belonging to the animal kingdom and related to the insects - the expression "Insects and other fungoid pests" being very common in the newspapers.

The rind fungus of the sugar-cane is an example of the microscopic fungi and it will not be out of place to briefly study its life-history. One of the most familiar objects in an

estate yard in Barbados at crop time is the heap of "rotten canes." If we examine these closely we find that they are covered by black curly hairs which have evidently burst through the rind of the cane. In the earlier stages these hairs appears as black dots about the size of a pin's head which raise the surface of the cane into little mounds. If we examine the hairs under a microscope which magnifies about 100 times we find that they are made up of thousands of minute brownish bodies, about $\frac{1}{000}$ of an inch long and $\frac{1}{8000}$ of an inch broad, resembling rice grains in shape, cemented together by a colourless gummy substance. These are the spores of the rind fungus, and they bear a similar relation to the fungus itself as a maize seed bears to a maize plant. These spores on account of their minute size are easily carried about by wind or by insects such as ants which are everywhere excellent spore distributors. On coming into contact with the internal tissues of a cane, *e.g.*, by means of the tunnels of the moth borer larva, the spore germinates in a day or two and sends out a minute colourless tube, a little broader than itself, which passes into the tissues of the cane, and if the conditions are suitable, increases rapidly in length, branches and gives rise to a network of tubes which extends right through the stem of the cane. The spread of the fungus can be detected from the outside by the well-known brown appearance accompanied by a certain amount of shrivelling. The growth of the fungus takes place entirely at the expense of the cane juice, the sugar being entirely used up, or rendered so impure as to be practically worthless. When the cane has been plundered in this way the filaments of the fungus generally proceed to provide for its dispersal, and for a possible unfavourable period by knotting themselves up into numerous cushion-like bodies underneath the rind. The contents of the filaments then pass into the tissues of these cushions and are used to produce spores which are pressed out through the rind as the hair-like bodies started with. This simple cycle of events constitutes the ordinary life history of the fungus a fact which has been completely established by extensive experiments carried out in Barbados under the direction of the Imperial Department of Agriculture. The behaviour of the rind fungus in the laboratory has been found to agree with its development in the cane itself. Starting with a single spore the whole life history has been followed out repeatedly under the microscope and the result has been in all cases the same. This method of experiment, which was originally adopted by Hansen in his investigations on yeasts, enables the investigator to obtain pure cultures of fungi, and by subsequent inoculation experiments on healthy host plants to determine whether any particular form found on diseased plants is really a parasite or merely a saprophytic form living on the dead remains of the plant which has been killed by something else. Proceeding in this way, the cause of any disease can be established beyond doubt. A scientific account of the results alluded to here were published in the December number of the *Annals of Botany* for 1900, and the paper was prefaced by a note by Sir

William Thiselton-Dyer, the Director of Kew, summarising results of the work done on the rind fungus.

It will be apparent that an exact knowledge of the life-history of a fungus is one of the things absolutely necessary to understand before we can make any intelligent effort in the way of fighting it. This is necessary in order to find out the weakest point in our enemy and to know where to direct our attack with the best prospects of success.

An exact knowledge of the life-history of a fungus, although absolutely necessary is by no means the last word on the subject. The problem is a much more difficult one, as it is necessary to elucidate the complex relations which always exist between the host and the parasite and to understand why under certain conditions of environment a fungus like the rind fungus of the sugar-cane is able to conquer the host-plant and to bring about such wide-spread damage as has in one or other of the West Indian Colonies occurred in recent years. Recent researches have done much to clear up this complex question and to indicate the directions in which such an enquiry should be conducted. These investigations, which are summed up by Professor Marshall Ward in the Croonian Lecture of 1890, have shown that it very frequently happens that when the conditions of climate and soil are such as to interfere with vigorous and healthy growth, a state of things obtains in the tissues of the host plant itself which favours the development of a fungus and enables it to gain the upperhand with great rapidity. On the other hand when the conditions of growth are such that healthy development goes on in the host then infection becomes difficult on account of the power of the plant to resist the attack of the fungus. Under these circumstances the inroads of the fungus become insignificant. Healthy plants, like healthy animals, have great disease-resisting powers. The recent epidemic of rind fungus in Barbados was universally put down to the unfitness of the Bourbon cane to resist disease, and the solution of the fungus difficulty was sought in the direction of new seedling canes and in the introduction of new varietie from other parts of the world. A more probable explanation of the epidemic, however, seems to be that the Bourbon cane as a result of the system of cultivation and selection then in vogue rather than on account of the unfitness of the variety, was in such a condition that it was unable to resist attack. The disease-resisting capacity of the Bourbon would depend on the methods of cultivation adopted and on the care exercised in selecting cane plants, and unless proper attention were paid to these points it is easy to see that after some years the canes would be unable to resist attack. It would appear that all we can safely say is that the Barbados Bourbon had little disease-resisting power and that had this variety been carefully selected and properly cultivated the result might have been widely different. The planters put the blame on the Bourbon rather than on their own methods. Unless some such explanation be accepted it is difficult to see why the cultivation of the Bourbon cane has not been given up in other parts of the West Indies.

That a close relation exists between the rind fungus and the sugar-cane is well seen by the occasional failure of infection experiments on very vigorous canes especially when young. When such experiments are made on weakly canes or on ripe canes which have stopped growing, infection takes place much more readily.

In this matter there is considerable scientific evidence, which is supported by much practical experience, that if we could ensure the planting of cane tops from vigorous and healthy canes, a suitable mechanical condition of the soil, which could only be obtained by proper cultivation, a sufficient supply of plant food and sufficient moisture, the inroads caused by fungus would be much smaller than at the present time. There can be no doubt that a thorough cultivation of the soil as it is understood in Great Britain, and according to the reports in the Sandwich Islands and in Louisiana, and a system of irrigation so as to be independent of any irregularities in the rainfall, are the directions in which fungoid attacks can best be fought and are also the directions in which the material prosperity of Barbados can best be improved. Artificial irrigation has been introduced on a small scale into Barbados with the best results, and it would not seem difficult to raise water for this purpose from the underground streams by taking advantage of wind power by means of windmills. By fighting a disease like the rind fungus on these lines a planter is to a very great extent independent of his neighbours—a point of some importance which will be readily appreciated when the drawbacks attending other methods of dealing with fungi are indicated. At the present time planters are practically agreed that the rind fungus makes much more headway when the canes have been subjected to long continued drought and they know from experience that provided the rains fall regularly they can look forward to a fair crop.

Besides the above suggestions, which have, from the point of view of fungoid attack, been, I think, put forward for the first time, and which are in the nature of preventive measures, there are two general directions in which it is possible for us to fight these pests and to keep them under control. They are defensive rather than offensive, and are based on the idea of attacking fungi at their weakest point and thus preventing their spread. As will be readily seen, although theoretically perfect, they have a fundamental weakness since their efficiency largely depends on the united action of agriculturists. For some reason or other, such united action of planters or farmers has rarely, if ever, been secured and consequently the methods about to be indicated have never fully realised the expectations of those by whom they have been put forward. Of these two main lines of attack, only one can, from the nature of the cane crop, be adopted in the case of the rind fungus. This method has reference to the destruction by burning of those parts of diseased plants which contain the more resistant fungus spores. In the case of the rind fungus this means the destruction of rotten canes since they contain the spores of the fungus in abundance, which are easily distributed and which under suitable conditions retain their vitality for long periods. So

far as my investigations have gone, I have very rarely found these spores on cane trash so that until it has been definitely proved that trash is a dangerous article there is no reason why any change in the present useful practice of mulching young canes with this substance should be made.

We are therefore limited to the method which depends essentially on the destruction of diseased canes. This, among other suggestions, was brought forward by the Commission appointed in Barbados in January 1893 to deal with cane diseases Little investigation of fungoid diseases on the spot seems to have been published during the two years this Commission was in existence. The conclusions of Mr. Massee of Kew on the life-history of the fungus were accepted without confirmation, a somewhat remarkable proceeding when one reflects that Mr. Massee's material only reached him after a long voyage when it would be naturally infested with the fungi which attend decay. Again, since fungi are as a rule extremely sensitive to differences of temperature the results obtained with a tropical fungus at Kew should not be accepted in the West Indies without confirmation.

Passing over the first two recommendations of the Commission dealing with the appointment of central and parish committees for the purpose of inspection and seeing the various remedies carried out we come to the suggestion which directs the soaking of all cane plants in a very dilute solution of carbolic acid. Unfortunately no experiments conducted on the spot to test this remedy are quoted in the report. Unless it could be clearly shown that rind fungus spores are killed by this solution there seems no point in bringing it forward.

Two recommendations dealt with cane trash, which was regarded as a dangerous article. Here again there is an entire absence of any positive evidence that cane trash contains rind fungus spores. So far as experiments have gone, it seems that the fungus confines its activities almost entirely to the stem of the cane where it finds an abundance of food material easy of access.

The fifth and sixth recommendations deal with the destruction of rotten canes. Dry rotten canes are to be burnt on the field, juicy rotten canes are to be crushed, the juice boiled and the megass burnt. There can be no doubt that this simple and inexpensive process is of the very greatest value and should be made a part of the estate routine all over the island. Unfortunately, however, the planters have not taken any general action in the matter. For some inexplicable reason they either allow the rotten canes to be collected by the workmen and stacked for fuel purposes for several months, or they carefully collect them into heaps so as to provide useful fungus nurseries for the benefit of their own and the neighbouring estates. This practice cannot be condemned too strongly. Planters should bear in mind that each rotten cane contains millions of rind fungus spores and that this storage of diseased canes is the very best thing possible for the spread of the disease. From the point of view of the sugar-cane, this practice is one of great danger. It is surely remarkable that instead of doing all in

their power to check one of their principal pests they at present are unconsciously doing all they can to spread it. The only argument against the destruction of rotten canes is that the proposal involves trouble at a busy time. But if the sugar-cane is worth cultivation at all, surely every means should be taken for keeping its enemies in check. The planters should remember that the rotten cane stage of the fungus is the only one with which they can hope to deal. The suppression of fungoid attacks by the burning of affected plants has so far been most successful in Germany, where the matter has been conducted under some kind of state control. It would be difficult to say how far such a method would succeed in an English Colony. If there is to be legislation on this question it should come as the result of a decided expression of opinion from the planters themselves. There can be no doubt that, under these circumstances, legislation on this question would be of the greatest benefit to the Colony. If, on the other hand, drastic measures were forced on the planters against their will, it is highly probable that the Government would find themselves involved in endless litigation.

In their ninth recommendation, the Commissioners suggest that when root fungus makes its appearance, ratooning should be given up. At the present time which is known as root fungus seems to be much more prevalent among ratoons than among plant canes. This is probably due to the present system of cultivation in vogue in Barbados. Beyond the application of artificial manure, and a certain amount of expensive forking, little seems to be done to the cane stumps after reaping. It is very probable that this want of attention to the stumps is the cause of a good deal of disappointment at the poor returns, and of the presence of root fungus. Some such method as that used in Louisiana, in which the soil between the rows is well cultivated by a digger, and in which the upper part of the stump is cut off by a shaving machine, would in all probability be the means of waking up the old cane stumps to renewed growth and would, no doubt, by removing unfavourable conditions, do much to eradicate root fungus. These operations would require skilful management as they would have to be performed at a time when rain is not very plentiful, and when there would be some danger of the stumps drying up if the operations were improperly conducted. Under an efficient system of cultivation many of the old roots would be broken off, the soil would be stirred up, and the old stumps would be to all intents and purposes ready made cane plants for the next crop. Planters should bear in mind that the mechanical condition of the soil is far more important than its chemical composition, and that, speaking generally, the benefits to be derived from thorough and skilful tillage are far greater than those to be obtained by the application of artificial manures. The Americans have realised this point, and hence we can understand the great attention they pay to cultivation, and to the mechanical analysis of the soil—the most modern methods of which being due to them. It should be remembered that without a proper mechanical condition of the soil, by which alone a healthy root develop-

ment is possible, a plant like the sugar-cane is soon retarded in its growth, and falls a prey to disease. Again without these suitable soil conditions, artificial manures have little or no effect since they are often washed off the land into the drains, and never taken up by the plant at all. Since during the main period of the growth of the sugar-cane the nature of the crop entirely precludes any cultural operations, we naturally find that the percolation of rain water has thoroughly consolidated the soil and that the roots and stumps of the cane are thoroughly sealed up in what is in some cases a practically impervious soil. In digging up stools affected by root fungus I have been greatly impressed by the manner in which the soil in this island packs round the cane stumps and the idea at once occurred to me that it is in the highest degree probable that the cultivation of ratoons in the manner suggested would prevent to a large extent what is known as root fungus, a disease which seems to be seriously affecting some of the most promising seedling varieties. The matter might be made the subject of extensive experiment.

The tenth recommendation deals with the eradication of the borer and fungus by cutting out affected canes and burning them. This is hardly practicable as far as the rind fungus is concerned since the disease does not usually make its appearance till the autumn or even later when it would not be possible to cut out diseased canes without doing much damage to the crop. Since the borer and fungus are to a great extent connected with each other the methods brought forward by the Imperial Department of Agriculture for the suppression of the borer should find a place in the routine of every well conducted sugar estate. Not only do the spores of the rind fungus gain entry to the canes by means of the tunnels of the borer, but also canes infested with borer are naturally weakened to a very great extent and are all the more liable to be rapidly killed by the fungus. When one reflects what an admirable substratum a ripe sugar-cane, the rind of which is perforated by numerous openings, is for a parasitic fungus and what feeble powers of resistance a ripe cane possesses, the necessity of keeping the borer in check becomes all the more apparent.

In their last recommendation the Commissioners suggest that rotation of crops should be adopted in the case of the root fungus. This recommendation should certainly be adopted by the planters in the case of both root and rind fungus as it is an excellent means of keeping in check the fungoid attacks of annual crops.

Three other points remain to be dealt with, viz., the practice, which exists in some of the West Indian Islands, of placing the rotten canes in the stock pens, the selection of cane plants and the raising of hardy varieties.

The practice of placing rotten canes in stock pens cannot be too strongly condemned. It is very probable that some of the spores will retain their vitality till the manure is applied

to the land and that many of the spores will be distributed by the animals themselves.

With regard to the selection of plant canes from the healthiest possible canes it would appear almost superfluous to refer to such an obvious precaution had not an example to the contrary recently come under my notice in Barbados. While on a visit to an estate during the present planting time I noticed a small field of very diseased canes, and, on enquiring what was to be done with them, I was solemnly informed that the canes on that field were to be used as plants. The attorney fully endorsed the suggestion of the manager who, in his desire to make as much sugar as possible, thought it wasteful to use the best canes for planting. This example, though probably exceptional at the present time, shows that old customs die hard, and that while there are many intelligent planters in Barbados who are quick to take up any practical suggestion, there are others whose devotion to old time methods is certainly most remarkable.

With regard to the suggestion of the raising of disease-resisting seedling canes, some general directions will not be out of place. Although the raising of seedlings from known parents by cross fertilisation, after the manner adopted by the Brothers Garton in the case of the wheat, would be a matter of some difficulty on account of the small size of the flower. nevertheless, it will probably be found practicable. In this way it ought to be possible to raise seedlings with any desired characters. With canes raised in this manner or as at present, it seems desirable that scientifically controlled experiments on their disease-resisting power should be made. In the case of the wheat, rust-resisting varieties have been successfully raised. It would seem that, from the planters' point of view, the disease-resisting power of a seedling is a very important factor in considering the question of its adoption on the estate. In addition to the present system of testing the disease-resisting power of seedlings by cultivation in plots and observing how far they have contracted disease it might be of service if suitable inoculation experiments were made in order to still more accurately determine what power the seedling possesses of resisting the entry and spread of the fungus. In conducting such experiments it would be necessary to grow the seedlings side by side in well cultivated, well manured and irrigated land and to perform the inoculation experiments on them. Their stumps could be treated as above described and their resistance to root fungus ascertained. Duplicate plots, treated according to the present methods, might be employed in order to determine if under these circumstances root fungus makes its appearance to a greater extent. If experiments on these lines were conducted during the experimental period of cultivation it is probable that useful knowledge as to the disease-resisting power of the seedlings under examination would be obtained. Probably some of the seedlings would come through the ordeal so much better than others that planters would be able to make a final selection of seedlings with great confidence.

In conclusion the suggestions for dealing with sugar-cane diseases contained in this paper may be summed up as follows:-

(1) The systematic burning of all rotten canes on every estate---the juicy rotten canes should be passed through the mill, the juice boiled, and the megass burnt. The utilisation of rotten canes by the estate workmen for fuel should be prohibited as well as their use in stock pens to make manure.

(2) The adoption on every estate of the suggestions made by the Department for dealing with the moth borer.

(3) Rotation of crops on badly diseased fields.

(4) The selection of healthy cane plants.

(5) The adoption of improved cultivation and of irrigation so as to raise the most vigorous canes possible and to be independent of an irregular rainfall.

(6) The efficient mechanical cultivation of ratoons as soon after reaping as possible, so as to diminish the risk of root fungus.

(7) The scientific study of the disease-resisting power of seedlings, and of all new canes imported into the island.

Of these seven recommendations, the first four have been brought forward before, and are here incorporated since they should prove of great use. The last three are new, and have been brought forward for the first time to-day.

DISCUSSION.

The PRESIDENT: Mr. Howard's recommendations for dealing with rind and root fungus may be stated as follows: (1) all canes on the estate should be kept in a vigorous state of growth, (2) they should especially be kept free from the attacks of the moth borer, (3) only thoroughly healthy canes should be selected for cane tops, and (4) all rotten canes at crop time, should be gathered from the fields at least once a week, passed through the mill, and the megass burned. You will agree with me that these are fundamental to the well-being, and success of sugar estates at the present time. I fully realize the practical difficulties that may be met with in carrying out these recommendations but planters must realize, that if nothing is done the fungus and moth borer will rob them of a large share of their crop, and their estates will become less and less productive. The treatment of ratoon canes referred to by Mr. Howard may be tried on a small scale and the results reported later. I am not sure how far it is suited to the West Indies. The question of hybridizing special canes under control for the raising of pedigree seedlings is a matter of great interest. So far nothing has been done in this direction. I am not without hope it may be possible to take up the subject. In the meantime I would earnestly urge on planters that they should make the selection of healthy

cane plants and the destruction of all rotten canes, the subject of special effort within the coming year.

Mr. W. D. SHEPHERD (Barbados): Can Mr. Howard tell us whether rind fungus and root fungus are one and the same disease?

Mr. HOWARD: In reply to Mr. Shepherd all I can say at present is that in all the cases of root fungus which I have examined where it was possible to find the original cane plant I have found rind fungus present in the cutting planted.

Sir GEORGE PILE (Barbados): With regard to the question of rotten canes on the estates over which I have control, I advise, and I think it is carried out, that all the rotten canes should be collected during the week, ground on Saturday afternoons and the megass burnt.

The PRESIDENT: May I ask, whether, on the estates referred to, the labourers are still allowed to carry away rotten and dry canes and stack them in their yards for fuel. This practice tends to spread the disease in the district.

Sir GEORGE PILE: Not to any extent.

Professor CARMODY (Trinidad): I have no personal experience in this matter, but I may mention that a practical planter, whose opinion I consider of some importance, has informed me that for several years his canes had been suffering a good deal from fungoid disease, but suddenly the disease disappeared altogether. He found that its disappearance was concurrent with the application of an artificial manure which contained a certain amount of sulphate of copper. It is well known that sulphate of copper is used externally for many diseases, but its internal application is rather a novel thing. As there are other planters who have used this particular manure if they would let us know whether they obtained similar results they might assist in the study of fungoid diseases.

Mr. WATTS (Antigua): The question of rind fungus is one of cardinal importance to all of us in the West Indies and I am glad to know that Mr. Howard's work has somewhat modified our earlier views on the subject. As the result of Mr. Massee's investigations a series of rules was published for the guidance of planters which they politely declined to follow. This was especially the case in the Leeward Islands with regard to the burning of cane trash, and I am glad that Mr. Howard has been able to say that the policy was a good one and that there is no need any longer to burn the cane trash. As to the method of combating the disease, I think that practical men are in accord with Mr. Howard's suggestions as to the collection and destruction of the rotten canes once or twice a week The selection of healthy vigorous plants seems to me the easiest and most practical way of combating the disease—a method which is adopted in many of the islands and in British Guiana. When speaking here last Conference I drew attention to a point which has long struck me, and that is, the universality of the disease. Nearly every cane on its drying up, whether apparently sound or unsound shows evidence of rind fungus. I believe this has an important bearing on the spread of the disease.

Mr. HART (Trinidad): In Trinidad the rind fungus is always with us and is found on the young plants as well as on the old canes, but there are clear differences in its effects on the various varieties, some being apparently very susceptible to the disease, others being practically immune. I am of opinion that the selection of seedling canes which are fungus-proof is the real solution of the difficulty. In following out the action of this fungus at the St. Clair Experiment Station, I have this year purposely left a large number of diseased canes on the ground. I did this with a view of ascertaining whether it is necessary to burn or carry away such a large quantity of rotten canes. I shall report the result at the next Conference.

The PRESIDENT: We have now reached the end of the papers specially relating to the sugar industry. We have covered a good deal of ground, and I trust those interested in the industry are convinced that we are doing all we can to be of service to them. The remarks offered during discussion have been of considerable value, for they have not only dealt with matters of immediate importance, but embody the experience of men well qualified to speak on the subjects under notice. In closing the discussion I would venture to ask for a larger share of support in the work of the Department from the body of planters especially in this island. I fully appreciate the kind help of those who give land for the local stations, but I should like to obtain facts and figures relating to the sugar industry that would, in no way, cause inconvenience or trouble to the planters, while at the same time they would greatly assist the Department in its efforts to help them. In all progressive communities, one of the essential conditions of success in any industry is accurate information with regard to the conditions under which it is carried on. That accurate information, so far, I regret to say I have been unable to obtain.

AGRICULTURAL EDUCATION AND ITS PLACE IN GENERAL EDUCATION.

BY THE REV. CANON SIMMS, M.A.

Principal of University College, Kingston, Jamaica.

In the two Conferences which have already been held we have dealt with the subject of agricultural education mainly on the practical side. We have taken for granted that, rightly or wrongly, public opinion in these Colonies is demanding a certain article, and have considered how far the schools are supplying it, and how far we can provide for their doing so

in the future. This method has placed us in possession of a very fair idea of what we are doing and what we propose to do in the immediate future. There is yet much left to be said on this side of the subject, and new developments will for some time probably make it a standing dish at our Conferences, but I think we may now profitably turn to deal with a question which has hitherto been only incidentally considered; the question how far in the interests of education we ought to supply the article which is being demanded, and what effect the teaching of agriculture will have upon the education given in these islands. No educator who has spoken here can have failed to consider this question, and to feel as Mr. Deighton last year said he did, that unless he was convinced that the proposed teaching was educationally valuable, he could not encourage the admission of it into his school. I propose, then, to consider the position and value of agricultural teaching as a part of general education.

We are being educated all our lives, but I confine the meaning of the word to the intellectual education which is the proper work of schools and colleges. Like other sciences, pedagogics is a progressive one, but it is at a disadvantage when compared with those sciences in which you can try an experiment and completely observe the results. In pedagogics the results are long in coming. It is impossible so to isolate the application of any subject or any new method, that results *post hoc* can be certainly considered results *propter hoc*. As my experience increases, I more and more shrink from that ready and specious method or accounting for economic and social phenomena. We are rather in the position say of the Physiologists in their International Congress in 1898, in face of the question of the effects of alcohol upon the human body, as to which they could only say that they were not clearly made out, and that they could not be appealed to as contradicting a certain specified conclusion. Where competent observers are thus uncertain, the pseudo-observer revels. In the educational world we teachers are informed that we are not 'practical men,' and that the 'practical man' knows what he wants and means to have it. The 'practical man's' theory apparently is that the teacher has only to put a pump into the well of truth, and then by pumping fill the receptacles set before him. The fact is that in questions as to what can be successfully taught the teacher is the practical man who understands the pump, and how far it is possible to fill the vessels--the minds which in most cases are not at all conscious that they need the process. As Thring, from whom I borrow the simile, says, it is like trying to pump water into a kettle with the lid on: a little gets in through the spout, and increased vigour in pumping wont improve the situation. With this protest, considering the fact that education means the preparation of the pupil to fill his place in life, and that such preparation must include technical as well as genera' preparation, how is this to be given? What can he properly expect from our schools? The problem differs according to the age at which the scholar leaves school. We may divide the classes of pupils into those who leave at 14, the elementary

class; those who leave at 16, the lower secondary class; those who leave at 18, the higher secondary class; and those who continue their education beyond 18, the university class. I proceed to consider the place of agricultural education as a part of general education in each case.

THE ELEMENTARY SCHOOL CHILD.

With the elementary school child we have to face great difficulties. Education in these islands in Jamaica at any rate is not in the air, as it is in Scotland or Saxony or Switzerland, with the result that the child of 14 with us is in the position of the child of 10 in such countries. In Jamaica, a few only get above the third standard, a great many do not reach even that position. The result is that there is very little opportunity of teaching anything beyond the three Rs. We are not infrequently met by the demand to drop them or cut them down to a minimum, and to teach practical agriculture. No teacher, no educational thinker, no one knowing anything of the possibilities of child nature can for a moment give in to this outcry. You must first temper and sharpen your tool the school child—to the extent of enabling him to read and write and deal with the elementary truths of form and number, before you can possibly with any advantage drop the attempt to do this in order to teach anything else. An attempt to do so is an attempt to go against all competent authority, a reversion to the non-educational system of the dark ages. On the other hand, when we proceed beyond this, it is now admitted that the child whose education is confined to books is insufficiently educated, that his powers of observation, and of drawing conclusions from what he sees, must be cultivated by object lessons and by elementary science. The smallest modicum of education beyond the necessary rudiments, which can be considered satisfactory, must include some teaching of this sort. It is further desirable that the child, where possible, should acquire some manual dexterity, some power of co-ordinating the action of head, eye, and hand, primarily by learning writing, then elementary drawing, and then anything further for which time and opportunity can be found. Now there is nothing whatever to prevent this elementary scientific teaching and this elementary manual training, which are educationally most important, being given on agricultural lines. The object lessons may be taken from the ordinary objects of country and agricultural life, the science may be the rudiments of the chemistry of the air and soil, the rudiments of biology, animal and vegetable, can be on economic lines and the training of the observing powers can be given through the observation of the salient facts of plant life. To this extent, then, agricultural teaching can be given in our elementary schools, all the children can be given some rudimentary ideas, and the intelligent and advanced ones can be trained to use their expanding powers in observation of the natural laws bearing on agriculture and in some little manual practice helpful to their future. I further think that there can be no more profitable expenditure of public money than in starting farm schools for picked children who have left the elementary

schools—children selected for their intelligence and industry from among the elementary school children and giving them training in agriculture for a year, or perhaps two years, restricting the book work to an hour or two daily, and spending the bulk of the time in the workshop and the field. This, however, must be done in a separate school set apart for the purpose.

BOYS AT SECONDARY SCHOOLS WHO LEAVE AT 16.

In this division of my subject, Mr. Deighton last year said much of what I feel inclined to say, and I shall begin by quoting him. 'All authorities are unanimous in insisting that a sound general education must be acquired before any special work is attacked.' This general education should include some science, and we at the Jamaica High School have been working on lines similar to those described by him as followed at Harrison College. We have the services of the Agricultural Lecturer for Jamaica appointed by Dr. Morris, for a few hours each week, who teaches the first form the *Tropical Readers*, the second form Cousin's *Chemistry of the Garden*, and the third form the elements of agricultural physics. I agree with Mr. Deighton that this teaching, so far from interfering with the advance of those boys who do not eventually take up the study of science, will educationally be a distinct advantage to them. Having thus far accompanied Mr. Deighton, I now proceed to mention some changes which I have thought over during the year, and intend to introduce into the Jamaica High School with the new century. They are the results of much thought and consultation with others. With us, boys in the third form pass the Cambridge Junior Local Examination, the average boy doing so when he is 15. The boy of the class I am now considering has reached this point in his general education, and has still six months or a year more at school. I have hitherto carried him a year further on the same lines, and have sent him in for the Cambridge Senior, or a second time for the Junior, according to his progress and ability. I have for years been gravitating to, and have now finally reached the opinion that this disposal of the boy's last year at school is a mistake, and propose, with the boy who has passed the Cambridge Junior, and is only staying six months or a year more at school to devote about half his time during this period to technical study, commercial or agricultural. I propose with all such boys to restrict the study of Latin and mathematics and to give more time to French; the commercial boy will give time to book-keeping, shorthand, prècis writing, and so forth; the agricultural boy will give two hours a day to practical work at Hope Gardens, and increase the time in school given to science. That is my present solution of the problem as to what technical training can be given in secondary schools to boys who leave at 16. I have some hopes of inducing the Cambridge Syndicate to add agricultural and commercial sections to their Senior syllabus, so that their examinations may continue to be our guide and test as they are at present in Jamaica.

BOYS WHO LEAVE SCHOOL AT 18.

These boys should in my opinion continue their general education, including the scientific teaching but not specializing until they are 16, and can creditably pass the Cambridge Senior Examination. Then they might restrict Latin and higher mathematics as the last class did a year younger, and specialize for eighteen months or two years in agricultural science including practical work at the Gardens, book-keeping, mensuration, and surveying, and the elements of economics, besides chemical and physical laboratory work. This is what I am aiming at, though want of means and limitations in my staff will put some limits, I hope not very narrow ones, to fully carrying out my plans. The full course would be that which I gave in some detail last year as suggested in a report made by Messrs. Fawcett, Watts and myself to the Government of Jamaica. The Agricultural Lecturer intends next term to begin a course of lectures, open to boys from any of the secondary schools in or near Kingston, which will go some distance in this direction, and will be capable, under the guidance of experience, of developing into a fuller course for intending agriculturists in our secondary schools.

YOUTHS WHO PROCEED TO A UNIVERSITY OR HIGHER TECHNICAL COURSE.

Of this class there is no need to say much. I do not think we can at present train them successfully in the West Indies. It is not that we have not men competent to do the work, but their time will be so occupied by the lower and more immediately necessary work which I have mentioned, and the demand for higher teaching will be so limited, that this work must, I think, be left to be carried out in larger centres, such as Guelf in Ontario, Cornell University, or some of the other good agricultural schools to be found attached to many universities. I have spoken at previous Conferences of the curricula at such schools and universities, and need not go into them now. It is just as justifiable, educationally, for the youth who has left school to specialize in agriculture as it is for him to specialize in law, medicine, engineering, or any other subject. His general education has finished at the end of his school life.

I have endeavoured briefly to traverse the whole subject. We are hardly yet in the full light of which Father Caroll spoke at our last Conference; but it is undoubted that the leading educationalists in these islands have had their thoughts strongly turned to this subject, which is also receiving much consideration in other parts of the world. That being so the streak of dawn of which he spoke can hardly fail gradually to brighten. The system of education of a country cannot be changed by the stroke of the pen, by a law or a code; the change can only come slowly and the results will become apparent more slowly still. We in Jamaica have begun training our existing elementary teachers, agriculture is being taught in our training colleges, the most conservative minds are being moved to admit that we must go on as we have begun, the Agricultural Lecturer is at work in the Jamaica

High School and is about to offer instructions to boys from other schools, the one lecturer, who gave part of his time to visiting proprietors and instructing small settlers, now gives his whole time to this work and we are about to start two more such lecturers. The dawn is brightening, but we must be patient, we must be reformers and not revolutionists, satisfied to move slowly and to test and secure our ground before we take the next step. The lines of action are opening up before us, and the Imperial Department of Agriculture may be satisfied that the system it has initiated has come to stay and to be an important factor in working out the evolution of economic life in these islands.

DISCUSSION.

Mr. POTBURY (British Guiana): We have commenced teaching the principles of agriculture in the elementary schools in Demerara, but owing to the want of a sufficient staff we have been unable to make much progress in the higher grade schools. As I said at the last Conference, we should be very glad if the Imperial Department of Agriculture could see its way to assist us in this matter.

The PRESIDENT: I wish it were possible to assist Mr. Potbury to obtain a Lecturer in Agricultural Science for British Guiana. I hope, however, the Government of the Colony will be able to see its way to obtain the services of a qualified man, preferably one who has made a special study of agricultural teaching. The Lecturer could not only give the necessary instruction at Queen's College but give assistance in lectures to teachers in training, to those in charge of schools, as well as occasional lecturers to planters and small cultivators in the country districts. Some action of this kind is absolutely necessary before the teaching of agricultural science can be started and carried out on right lines in the Colony.

TEACHING THE PRINCIPLES OF AGRICULTURE IN ELEMENTARY SCHOOLS.

BY THE HONOURABLE T. CAPPER, B.A., B.Sc.

Superintending Inspector of Schools, Jamaica.

I have been requested to say something to the Conference on "Teaching the principles of Agriculture in Elementary Schools," and in this connection to give a short summary of the provisions of the new code which came into force in Jamaica last May. At the outset, I think it is only fair to the Confer-

ence to make my own position clear on the subject of the extent to which it is possible or desirable to give an agricultural trend to the instruction given in elementary schools. I cannot agree with some in thinking that it is possible for "agricultural science to be the primary thing in elementary schools," or for "elementary schools to do what the apprenticeship system did in the way of preparation for the future life." If elementary schools come to be regarded as existing mainly for the purpose of teaching agricultural science it is certain that no education will be given in them worthy of the name, and that they will fail entirely to attain even their ostensible object. The apprenticeship system gave apprentices a thorough practical knowledge of their trade by keeping them hard at work, for three, four or five years. Mr. Fawcett explained at the first of these Conferences what this meant in the case of gardening. The school can never give anything that can possibly take the place of this. From the day a child enters an elementary school the one paramount object to be aimed at must be the all-round development of his nature, intellectual and physical. The elementary school cannot and should not attempt to train him to be a lawyer, a doctor, a theologian, or an agriculturist. The ideally successful elementary school will send out its scholars with every faculty of mind and body trained to the highest point of perfection in observation, perception, ratiocination, readiness and accuracy in the use of hand and eye, and with a knowledge, thorough and accurate rather than extensive, of the elementary principles upon which all arts and sciences are based and of the main facts in nature, history and economics. This ideal can, of course, never be attained, and it is only in isolated and exceptional cases that it can be even approached. In places like the West Indian islands, where agriculture must be the occupation of the vast majority of elementary school children, it behoves us to make sure that the greatest possible use is made of agricultural facts and principles in the furtherance of our main object, the all-round development of the child's nature. And it must not be supposed that this imposes narrow limits on what may be called the agricultural side of that development. In the admirable circular issued by the Board of Education in England in April last it is shewn how nature-study is specially adapted to draw out the child's faculty of observation, and how manual dexterity may be obtained by the use of common tools. The ideal presented by this circular is much the same as that set forth by Colonel Hicks at last year's Conference. It is a high one, utterly unattainable for very many years to come, but one to which we may hope to draw nearer year by year.

In Jamaica, especially since the formation of a Board of Education eight years ago, I may say that the importance of laying stress on the agricultural side of the child's development has been always present to us. In the first code of 1898 the syllabus for elementary science was specially framed with this in view, and provision was made for special grants for box-cultivation, and higher grants where anything in the way of scientific cultivation was successfully attempted in the field

out of school hours. In the revised code of 1895, detailed regulations were issued governing these grants and a new grant for tools was provided for. In 1899 the teaching of agricultural principles under the head of elementary science was made compulsory and special grants for this were discontinued, but they were and are still given for cultivation in the field out of school hours. Finally, in the revised code issued last May, a largely increased number of marks was allotted to elementary agricultural science (12 per cent. of the total as against 7 per cent. in former codes), and the schedule of requirements for elementary science in school, for the special grants for cultivation out of school, and for agricultural science in training colleges, was entirely re-cast with the assistance of the Lecturer in Agricultural Science, Mr. W. R. Buttenshaw. These schedules were however hastily drawn up, and are still provisional and tentative—they will be considerably amended and expanded this year.

In elementary schools at present the science taught is divided into two sections for each division. The first section deals with general science or nature knowledge, beginning in the lower division of the school with lessons on domestic and wild birds and animals, proceeding in the second division to elementary physics, dealing mainly with the properties of air and water and common atmospheric phenomena, and ending in the highest division with the elements of hygiene. The second section is specially devoted to plant-life and agricultural science, commencing in the first division with the study of plants as growing things, with simple lessons on the more useful plants in Jamaica, such as sugar-cane, coffee, etc., proceeding in the second division to the general conditions of plant-life and the functions of water, soil and air in furnishing plant-food; and in the third and highest division dealing with the different kinds of rocks and soils, their formation and improvement by tillage, drainage and manuring, requiring on the part of the scholars familiarity with the use of the various tools and the care necessary to keep them in order, with an extension of the work in the lower division on the growth and preparation for market of the principal Jamaica crops. Special stress is laid on the importance of growing plants in the schoolroom for purposes of illustration, and the imparting of knowledge respecting them by means of practical illustrations and simple experiments. The grants for out-of-school cultivation, as in previous codes, range from £5 to £10 for the year, besides special grants for tools. The conditions on which these grants are given are, amongst others, that at least a quarter of an acre of land shall be provided and shall be used as an experiment ground all cultivation being carried on on scientific principles such as those laid down at the Agricultural Experiment Station. It is too early yet to report on the results of the last code. None of the schools have as yet been examined under it, since it was only enforced at the beginning of the present year. Still, without examination, a general idea may be formed as to what is being attempted and done. At present I regret I am unable to report any very tangible results. I cannot do better than give *in extenso* the observations of Mr. Strickland, the Inspector for the banana

growing districts of St. Mary and parts of the adjoining parishes on the subject. He says:

"Only in rare instances do I meet with any attempt at practical cultivation in connection with the work of a school. What is seen in this direction generally consists of small beds of flowers and small shrubs or trees near the school-house. In these cases the work of the children appears to consist mainly in giving a little time to picking off caterpillars and to watering the plants. Very little seems to be done in the way of hoeing, digging seed-beds, etc. The teacher at one school is a most exceptional man, and has shewn some indication of beginning a systematic method of cultivation by way of instructing the children and I hope to see some satisfactory results from him. He has had the school for only a short time, and is proceeding cautiously, having to combat the unwillingness of the parents to allow their children to do any manual agricultural work at the school. Being a man of some originality, and with a good deal of common sense he will, I think, in time, remove the difficulties arising from the attitude of the parents. He is, however, the only teacher I know who seems to possess the tact necessary to enable him to overcome and remove this objection. He may ultimately fail, but, at the present moment, I anticipate some success for him. This objection on the part of the parents is a very real one and demands due consideration in any scheme of agricultural teaching in elementary schools. Nothing will be gained by ignoring it, and it will be impolitic to endeavour to force it aside. It will gradually disappear as a wider intelligence spreads among the people. At the present time it unmistakeably exists as a strong prejudice, and to neglect its consideration as an important factor in any scheme of agricultural teaching will be to court failure. Whilst an occasional teacher, here and there, may succeed in combating it for a time I fear the prejudice may crop up at any time in such cases, and I very much doubt if the majority of teachers can make any headway against it, even if they wish to do so. This consideration and the lack of training in practical agriculture on the part of many teachers lead me to think that, even if no other reason existed, it would be advisable and more useful to prescribe some course of agricultural training in elementary schools which does not involve much beyond box-cultivation. At any rate this should I think be the course for some time. If we press too strongly for the teaching of practical agriculture in the school, we shall, I am afraid, defeat our purpose."

"Since the introduction of Blackie's *Tropical Readers*, a more intelligent appreciation of plant-life and of agriculture has been apparent in the schools on the part of both teachers and children. Further, the children take home the books and read them by themselves, and the parents often peruse them. I am inclined to think that a free use of the *Tropical Readers* should be insisted upon, and that inspectors should be instructed to examine mainly on their contents. Where there is reason to know that a teacher has had a suitable training or shows a suitable capacity, box-cultivation should be insisted upon with suitable simple lessons in object teaching to demon-

strate elementary agricultural principles. It is proposed that Mr. Buttenshaw and myself should prepare a scheme for such teaching."

"I have observed a gradual improvement taking place in the methods of cultivation followed by the settlers in any district, and I trace this improvement to imitation of improved methods introduced on the larger cultivations. An appreciation of the benefits following a free forking of the land, for instance, is being realised among small cultivators. The people are still in the imitative stage of civilisation, and I am inclined to think that the best possible improvement in agriculture among the lower classes of the inhabitants can be more readily brought about by bearing this imitative tendency in mind. To send round lecturers to give lectures and demonstrations to the people, perhaps in connection with the local branches of the Agricultural Society, would, I believe, bring about better results in a short time than anything done in connection with the schools. This, to my mind, is the most important method of agricultural teaching, and one that should receive immediate consideration. Mr Cradwick's visits for this purpose to different parts of the country have done much good, and I believe the Agricultural Department could do most useful work by increasing the number of such men, and the frequency of their visits to districts. Different men might take up different subjects and follow one another."

"If provision could be made for settling youths of the peasant class, who have been trained at Hope Gardens or elsewhere, on small holdings, the surrounding people would quickly imitate the methods of cultivation followed by such when they noticed better results ensuing. The youths might be more specially trained for the class of cultivation most suitable for the district in which they are to reside. The training might be given by means of scholarships from the elementary schools. Safeguards would have to be devised, just as safeguards already exist in the case of teachers trained at the expense of the Government."

"I am strongly of opinion that, for some time, something on these lines will be more satisfactory than looking mainly to the elementary schools. Let good foundations be laid by giving instruction in the principles of agriculture in the schools, but for more immediate results I feel satisfied that we should look to some such system as I have briefly indicated. We need to give more attention to teaching the adults who have shewn themselves very willing and often eager to learn."

It will be observed that Mr. Strickland speaks of box-cultivation as only practicable in special cases, whereas the code recommends it universally. There is less inconsistency here than might appear. For some time, in Jamaica at least—it may not be the case in more favoured islands—we shall have numbers of schools where the teachers are quite incompetent to carry out satisfactorily any system of box-cultivation, and where the circumstances of the school make such cultivation extremely difficult. I fear therefore we cannot look for speedy

results in Jamaica. We greatly need elementary text-books suited to tropical conditions. I would willingly join in the cry "away with text books" if we could only secure teachers capable of doing without them. Till we can do this, text-books are essential. We have all, I think, been anxiously looking for the adaptation to West Indian conditions of the memorandum of the French Education Department published in the last issue of the *West Indian Bulletin*, which we were led to hope, from a sentence in a recent despatch of the Secretary of State for the Colonies, would shortly be published by the Imperial Department of Agriculture. An elementary text-book in agriculture has just been published by Messrs. Blackie in three parts of which the first two strike me, from the cursory perusal which is all I have yet been able to give them, as needing very little adaptation for the West Indies. The third would require to be altogether re-written.

To insist on more than can be fairly expected from such of our teachers as are still imperfectly trained and educated, under penalty of forfeiture of the whole grant, would be impossible. With the majority of our people steps are not taken to ease the shoe until it actually begins to pinch, and when teachers find that the schools lose much more heavily than heretofore in grants, when elementary agricultural teaching is not satisfactorily given, we shall soon find them putting forth every effort in their power to give that teaching.

Mr. Strickland travels somewhat outside the special topic allotted to me of "Agricultural Teaching in Elementary Schools," but his remarks appear so pertinent to the main object of these Conferences that I thought I might venture to include them. As an illustration of the imitative spirit referred to by Mr. Strickland, and at the same time of the advantage of general culture even in agriculture, I may refer to an incident that came under my own notice. I had been visiting a piece of land of about 50 acres which was being successfully and scientifically cultivated in ginger by two energetic orange growers from Florida who had been driven out by the disastrous frosts of a few years ago, and on my return I passed a small patch of a quarter of an acre of ginger cultivated by a man who had gone through a good part of the course of training for a schoolmaster, but had left college and given up the profession of teaching. He had, I was given to understand, realised a clear profit of £20 out of his quarter of an acre of ginger in the preceding six months, and this from intelligent observation and imitation of the methods of the larger cultivators whose fields I had just visited.

Of grants for out-of-school cultivation only about ten have as yet been given in the year, although every encouragement is given to teachers to work for them. The imitative tendency spoken of by Mr. Strickland is again illustrated by the fact that five of these are within a radius of ten miles and three within a radius of two. Of two typical examples of these the Inspector who examined them reports: "The work was of a distinctly scientific character, bananas, coffee, cocos, cane, kola, corn, etc, being grown on experimental plots, some well cultivated, others not. Plots were laid out for ordinary

cultivation near others specially prepared, to show the difference in results, and lessons were given in grafting, pruning, etc. I am sure that if many teachers in the country districts carried on the same work as the teachers at Caledonia and Long Hill the result could not fail to be of great practical advantage to the children, and a wholesome object lesson to the neighbourhood."

With regard to three other schools which did not obtain grants, he reports: "Practical work of a more or less scientific nature is carried on, but on plots of ground much too small to satisfy the requirements for the special grant, as the code requires a least a quarter of an acre. Potatos, cocos, corn, coffee, tobacco, etc., are cultivated and the value of cultivation is shewn by growing the same plants side by side on cultivated and uncultivated plots."

Mr. Buttenshaw will, I understand, speak on the course of agricultural lectures given to about thirty teachers at the Hope School last August, and will doubtless say something about the course of instruction given by him in three of the Training Colleges. I may point out, however, that with two or three such courses a year, which is as much as we can expect to manage, it would take ten years for all our 800 teachers to get the benefit of this instruction I would further observe that if, as I believe was the case, the keen interest shown by the teachers in the lectures and the copious notes taken were due as much to a desire to make practical use of the knowledge so gained for their own private benefit as to a wish to improve their teaching in the elementary schools, the lectures need be considered none the less successful on that account. The good effect on the teaching will still be produced, and at the same time the imitative faculty spoken of by Mr. Strickland will come into play in the case of the peasant cultivators in the neighbourhood, who will be the first to note the successful application by the teachers of the lessons received at Hope. Nor is the cultivation for their own benefit by the teachers to be at all discouraged It will be many long years before we see the elementary schools in the country districts of the West Indies open for more than four days a week; and equally long, I fear before the islands can afford to pay such salaries to their teachers as the importance of their work deserves. The application of the superior intelligence and greater knowledge of the teachers to the work of cultivation is therefore altogether desirable, and will have a strong tendency to promote what we all have at heart, the advancement of agriculture in the West Indies.

DISCUSSION.

The PRESIDENT: It is fully recognised that the teaching of agriculture in elementary schools must be started on simple lines and some time must necessarily elapse before we can hope to cover the whole ground. Mr. Capper's paper was prepared before he heard the address of to-day. I have again urged that "we cannot attempt to teach practical farming to children in elementary schools." With regard to the adaptation of the Memorandum of the French Education Department to West Indian conditions, referred to in a recent despatch of the Secretary of State, I may mention that a little book entitled *Nature Teaching* prepared at my request by Mr. Francis Watts, is already in the press and will be shortly issued. This should meet all the immediate requirements of teachers and place them in a position to carry on both the theoretical and practical teaching on right lines.

MR. W. R. BUTTENSHAW (Jamaica): Agricultural teaching in elementary schools has, during the past year, received considerable attention in Jamaica. The new code which came into force in May 1900 makes agricultural science a compulsory subject in the training colleges and elementary schools.

In the training colleges, the first year students have a course of elementary science preparatory to the study of agriculture, and are also required to possess an intelligent knowledge of the *Tropical Readers*, The second year students are required to pass an examination in the following subjects:—The composition and action of the atmosphere. The origin, formation, constituents and properties of soils. Plant structure and plant life. Tillage, drainage, irrigation, and manuring.

In addition to outdoor cultivation, experiments and illustrations, such as are recommended in the French scheme of agriculture for elementary schools, with plants grown in boxes receive attention. Disused soap boxes and kerosene tins are used for these purposes. In the elementary schools the teaching follows the lines of instruction given in the training colleges. All schools are required to illustrate the teaching in elementary science, general and agricultural, by experiments—including simple experiments on germination, life and growth of plants, the different kinds of soil and their improvement, and the use of manures—carried on by means of plants grown in pots or boxes. In addition to this an extra grant is given to those schools which cultivate a plot of land of at least a quarter of an acre on scientific principles as taught to teachers and training college students.

On my arrival in Jamaica in January of last year, I found that no plan of agricultural instruction had been arranged, but I was consulted in the drawing up of a scheme both for the schools and training colleges. During the year I have lectured to the students in the three colleges of the island, on an average of four times a week. At the Mico Institution seventy students have been receiving instruction, at Shortwood twenty,

and at Bethlehem twenty. At the Mico College a large piece of land is under cultivation by the students, who thus receive instruction in the growing of certain crops and in the use of tools and implements.

One course of lectures has also been arranged for teachers already in charge of schools. This course lasted for three weeks and was attended by thirty-six prominent elementary schoolmasters from the neighbourhood of Kingston. The entire expense of this course was borne by the Government. In addition to the lectures, the teachers worked in the Hope Gardens two and a half hours daily, and showed considerable interest and keenness in both the practical and theoretical work, and good results may be looked for. One of the leading Kingston merchants also gave them a very instructive lecture upon preparing and packing produce for market. This course was considered somewhat of an experiment and as a result the Superintending Inspector of Schools is arranging for similar courses at various centres in the island.

Rev. J. E. REECE (Inspector of Schools, Barbados): As the result of the examination held after the first course of lectures to elementary school teachers delivered by Mr. R. R. Hall and Mr. J. R. Bovell in 1899, twelve masters were deemed competent to impart instruction to their pupils in agricultural science. Copies of Blackie's *Tropical Readers*, Books i. and ii., were given to the schools under these teachers, and the boys in standard iv were expected to prepare from page 68 to page 181 of the first book, and the boys in the higher standards from page 58 to page 183 of the second book. The examination was held during the first week in December. Nine of the teachers presented pupils for examination, eighty-six fourth standard boys were examined on the first book, and sixty-six per cent. passed. In the higher standards 110 boys were examined, and fifty-eight per cent. passed. Thirty of those who passed in the first book obtained over seventy per cent. of the marks, and five of these gained over ninety per cent. In the higher standards twenty-two boys obtained over seventy per cent. of the marks given. The answers sent up by many of the candidates showed that a good deal of pains had been taken by the teachers in imparting instruction to their pupils in this subject, and I consider the results of this, the first examination held in this subject, highly satisfactory.

The class list, issued after the examination on the second course of lectures delivered by Messrs. Hall and Bovell, shows that thirteen teachers were placed in the first rank. During the present year these teachers will be allowed to prepare pupils in this subject as soon as they have obtained the necessary books.

I am sorry to be unable to report much progress in the practical part of the subject. One teacher living near his school has a very small garden of which he has made the most, and has given instruction to his pupils in the cultivation of garden plants and the budding of roses.

I regret that the suggestion, made at the last Conference, that prizes should be offered at our agricultural exhibitions

for the best specimens of pot plants grown by boys in our elementary schools, has not been taken up. I feel sure that if this were done the boys would be encouraged to take a greater interest in the practical part of the subject, and be stimulated to bestow care and attention in the rearing and cultivation of plants.

Mr. W. BLAIR (Inspector of Schools, British Guiana): At the last meeting of this Conference I concluded the few remarks I made on the subject of agriculture in primary schools by saying that if it should be my privilege to attend another, I trusted that I should be able to tell you of something attempted, of something done. I am here to-day to redeem that promise.

Shortly after my return to British Guiana, His Excellency Sir Walter Sendall, G.C.M.G., induced the Combined Court to vote the sum of $1,500 for agricultural instruction, and it was thought that the money could not be more judiciously spent than by giving instruction to schoolmasters in agricultural chemistry and botany, thus qualifying them to impart knowledge in these subjects to their pupil-teachers and scholars. In the preparation of a scheme I was associated with two gentlemen, your late Attorney-General the Hon. H. A. Bovell, and Professor Harrison, whose names are household words in Barbados, upon whom devolved the duty of preparing the syllabus of subjects for study and the selection of chemical apparatus for the use of the students. Before the end of May all the initial difficulties had been overcome, and a notice was sent to the *Official Gazette* inviting those certificated teachers who were anxious to attend the course of lectures to apply for cards of admission: with the result that twenty-five resident in Georgetown, and thirty more in the immediate vicinity, expressed their desire to avail themselves of the privileges offered by the Government. I was absent on leave when the first meeting was held, but my *locum tenens*, Mr. H. W. Seonee, M.A., entered heartily into the work, and at the first meeting, at which were present His Excellency Sir Walter Sendall, the Hon. H. A. Bovell and Professor Harrison, he explained in a few well chosen words the design and scope of the lectures. He was succeeded by Mr. Bovell, the Governor and Professor Harrison, each of whom said a few kind words to the teachers present, and the project appeared likely to turn out an unqualified success. Professor Harrison, the officer-in-charge of the lectures, appointed his laboratory-assistant, Mr. W. P. Kaufmann, and Mr. J. F. Waby of the Government Botanic Gardens, as lecturers, the former in chemistry, and the latter in botany. The syllabus of the lectures in agricultural chemistry is, so far as I can judge, very complete and exhaustive, and the same may be said of that in botany. To encourage the lecturers the Government allowed a small honorarium for each lecture, and allowed second class railway fares to all the country schoolmasters attending them, and conveyed the teachers free of cost from the Orphan Asylum schoolroom, the building in which the botanical lectures were given, to the laboratory of Queen's College. It was also decided that all those who showed special aptitude in their work, as

evinced by an examination to be held at the close of the course of lectures, and who obtained an honour or first class certificate, should receive, free of cost, practical instruction in agricultural chemistry, and would be admitted to demonstration lectures at the laboratory of Queen's College, and those who showed marked aptitude for agricultural science would be placed under the direct tuition of Professor Harrison at the Government laboratory and of the Government Botanist, Mr. Jenman. It was confidently hoped that we should be able in this way to train a number of men whose services would be available for the instruction of pupil teachers and teachers of schools in the country. The notice in the *Official Gazette* stating that at the close of the course of lectures the students would be required to submit their attainments to the test of an examination, had, apparently, the effect of reducing the attendance of the town teachers by nearly 50 per cent. A week or two later the question arose as to whether a country teacher was entitled to receive the train fare when he had travelled on his bicycle. The Government decided in the negative, and at the conclusion of the lecture in chemistry on Saturday, November 17, one of the teachers, deputed by the others, informed Mr. Kaufmann that they, as a body, had decided to cease attending the lectures. At the lecture to town teachers on the following Monday only one attended, and Mr. Sconce, with the approval of the Government, issued a notice stating that for the present the lectures would be discontinued. One of the teachers, I am informed, stated that the money spent on chemicals and apparatus, the honoraria to the lecturers, and the travelling expenses of the teachers, might just as well have been thrown into the sea. It would be difficult to conceive a more trivial excuse than that originally put forward by the town teachers as a reason for their refusal to continue their attendance at the lectures. The *Daily Chronicle* newspaper refers to their action as the "Teachers' Strike" and comments on it as follows:—
"On the authority of the statement published yesterday and signed by Mr. Robertson, the President of the Teachers' Association, it will be seen that their action is inconsistent and unwarrantable. Their pretext for abstention, first of all, is the treatment afforded one of their number regarding travelling expenses. They then changed their ground and converted their act into a protest against the new regime of the Education Department. They profess their highest appreciation of the instruction they received in science and of the gentlemen who imparted it, yet they feel no compunction in throwing their opportunities to the winds, and behaving after the manner of their own most unwilling and unruly pupils."
I returned to the Colony a week after the strike and was requested by some of the teachers who had taken no part in it to make arrangements for the resumption of the lectures. This has been done. The number attending the lectures will not be so large as it was at first, but I am still hopeful that some good may result from our efforts. While on the subject of lectures I may say that during my recent visit to Barbados, on a holiday, through the courtesy of Dr. Morris I was per-

mitted to attend one of Mr. Howard's lectures at Harrison College. The lecture left nothing to be desired. All the scientific terms and chemical formulae were written on the black-board, drawings of all the botanical specimens were made and afterwards copied into the students' note books, some of which were patterns of neatness, and all appeared to take an intelligent interest in the subject matter of the lecture. Your success has made our failure all the more disappointing.

Since I last had the pleasure of addressing this Conference our Educational Regulations have been revised and amended, and considerable attention has been paid to the subject of agriculture. Any school in which practical and theoretical instruction is given for not less than two hours a day for more than 100 days during the year may earn $7.50 for each scholar. Scholars in standards vi, vii, and viii in any school who can answer questions to the satisfaction of the inspector on the subject matter of Blackie's *Tropical Readers* are paid at the rate of $1.00. All male pupil teachers are required during their second and third years' course to study and pass an examination in Blackie's text books, and at the end of the fourth year to be familiar with the elements of tropical agriculture. Our text book is the admirable essay written for the Government of Jamaica by Dr. Nicholls. During the last year of this course they will be required to attend a course of lectures in agricultural science and to pass an examination in the same. Hitherto agriculture has been an optional subject at the examination for teachers' certificates, but I propose to make it compulsory, and I hope in this way to train a staff of teachers who will be well qualified to impart instruction in this most important subject.

Before closing my remarks I should like to mention that one of our teachers was evidently impressed with that part of Dr. Morris' last address which referred to scholars' gardens and the growing of plants and flowers in boxes and tubs, and encouraged his scholars to grow them at their own homes. I was asked to open the show yesterday but my engagement here prevented my doing so. I do not know what was done, but the Acting-Governor, Sir Cavendish Boyle, thought sufficiently highly of the show to give ten dollars in prizes.

RESULTS OF TEN YEARS' EXPERIENCE WITH COMPULSORY ENACTMENTS IN THE LEEWARD ISLANDS.

BY C. M. MARTIN, B.A.

Inspector of Schools for the Leeward Islands.

The present educational system of the Leeward Islands dates from 1890 when, by Law 14 of that year, compulsory education was introduced. This Law provides, generally : (1)

for the appointment of educational district officers, (2) for enforcing the obligation on parents to cause their children between the ages of five and twelve to receive efficient elementary education, (3) for restricting the employment of children of school-age, (4) for the erection of school-buildings in places insufficiently supplied with schools, and (5) for the establishment of local Education Boards. Efficient elementary education as defined by this Act means the instruction given at any State-aided school. The term parent is widely defined as including a guardian and every person who is liable to maintain or has the custody of any child, and every male person co-habiting with the mother of any child whether he be the parent of that child or not. By this Act the Governor-in-Council may by proclamation declare any portion of the Colony an educational district, and he has the power to appoint one or more educational district officers to carry out the provisions of the law. The duties of educational officers are laid down as follows: (1) they shall keep a register of all children under the age of twelve, whether under the age of five years or not, residing in their districts; (2) they shall ascertain and report to such persons as are named by the Governor the names of all persons neglecting to cause their children to receive efficient elementary education; (3) they shall enforce the provisions of the law and prosecute all persons not complying therewith; (4) they shall sue for and recover all school fees, and generally follow such directions as may be laid down for their guidance by the Governor-in-Council. Efficient elementary instruction in reading, writing and arithmetic is made compulsory and parents habitually and without reasonable excuse neglecting to cause their children to receive this instruction may be brought before a district magistrate on the complaint of the educational district officer. The magistrate may order that the child shall attend at a school of the parent's selection or, if he select none, at such school as the magistrate may think expedient. A "reasonable excuse" is defined as follows: That there is not within two miles measured by the nearest road from the residence of the child any public elementary school at which the child can attend or that the absence of the child from school is due to illness or other unavoidable cause. In this Law, there are ten clauses which regulate the employment of children of school age, but as this portion of the Act has never been enforced it may be disregarded in this brief review. The school-fees to be paid under this Law are fixed at one penny per week, and at industrial schools at not less than sixpence for each child for each week, and, if a parent has more than one child attending school, at not less than four pence per week. Exemption from the payment of fees may be granted on a certificate from the educational district officer that a parent is unable from poverty to pay any fees, and the fees of such children so exempted may be paid by the Governor to the managers of the school.

As regards the supply of schools the Law provides that if before the first day of July 1891 there is insufficient school accommodation in any educational district the Governor

may erect, establish and maintain sufficient schools in such district, such schools being called "Colonial schools." Two such schools have been established in Antigua and in Dominica, for special local reasons, where all the schools are Government schools.

With regard to local Education Boards it should be noted that none exist at present in the Leeward Islands, nor has there arisen any demand for the establishment of these boards. Law 15 of 1890 enacts that an Inspector of Schools shall be appointed, and the Governor is authorized to frame rules for the more efficient working of the Education Act. By this Law also it is provided that no school shall receive a grant-in-aid which is not open to inspection by the inspector or which, in his opinion, is undeserving of aid. By Law 11 of 1890 an elementary school had been defined as a school or department of a school at which elementary education is the *principal* part of the education given. This definition is repealed by Law 7 of 1891 which defines, for the purposes of the Education Acts, an elementary school as a school or department of a school at which elementary education is *part* of the education given and which is registered pursuant to the provisions of this Act. Efficient elementary education is now defined as (1) instruction given at a public elementary school, (2) instruction given at any school registered pursuant to the provisions of the Act and conducted by a person who shall have first obtained from an inspector or assistant-inspector of schools a certificate of competency to impart efficient elementary instruction, (3) private instruction received other than at school provided that the person giving such instruction shall have first obtained a certificate of competency to impart efficient elementary instruction.

Clause 4 of this Law states that no school shall be kept in any part of the Colony unless the same shall have been first registered pursuant to the provisions of this Act, and no school shall be kept in any building and place which is not in conformity with the rules to be made for such purpose as provided in this Act. The Law gives power to the Governor-in-Council to make rules for the efficient carrying out of the provisions of the Act.

After this brief review of the provisions of the three Education Acts of the Colony, I now propose to show what has been the result of the introduction of compulsory education as exhibited in the school attendances. In 1880, the year before the introduction of the first compulsory Education Act, the number of scholars on the books of the State-aided schools was 12,500, with an average attendance of 6,900. In 1890 these numbers had risen approximately to 13 600 and 7,500 respectively. In 1891 there were 17,600 children on the roll and 8,200 in average attendance—an increase of 5,000 in number on the books and 1,500 in average attendance. Compulsory attendance was enforced in the middle of the year 1891 in the principal towns of the Colony, and also in Montserrat and Nevis. Wisely as it proved, the enforcement of the Acts was gradual, for the increase in the numbers on the roll in the educational

districts, formed in 1891, range for that year from 30 per cent. in St. John's to 90 per cent. in Montserrat and in average attendance from 30 per cent. to over 90 per cent. How great a disorganization this rapid increase must have caused in schools many of which were insufficiently supplied with accommodation, appliances and teachers, may well be imagined.

In 1892 the numbers on the roll rose to 21,500, and the average attendance to 10,000. Since 1889 the increase in the numbers on the books had been to this year (1892) approximately 70 per cent., in average attendance 47 per cent. In June 1892 the whole Colony was proclaimed an educational district under section 3 of Act 11 of 1890. From the end of 1892 then, we have figures which will show the effect of compulsion as regards the schools of the whole Colony. In 1893 the number on the roll was 23,500, and this rose yearly until 1896 when the number stood at 25,139. The average attendances for the two years referred to are respectively 11,400 and 12,900 The year 1896 marks the high-water mark of both numbers on the roll and average attendance of the schools of the Colony. In 1897 the numbers under both these heads fell off by about 400 in each case and while in 1898 there was a temporary rise in the numbers on the roll, the average attendance was nearly 1,200 less than in 1897. In 1899 the number on the roll was less than in 1898, a fact for which at present I cannot account, but the average attendance had recovered some of the ground lost since 1897. The recovery, however, is due simply to improved attendance at the schools in Dominica and in the Virgin Islands, both of which Presidencies show a surplus of revenue over expenditure. It is worthy of note in this connection that the lowest point reached by the average attendance, viz., that in 1898, coincides as regards time with the lowest average price of sugar and that the decrease in average attendance during the years under review has occurred only in those islands of the Colony which are mainly or entirely dependent upon the sugar crop. Finally, under this head the improvement in the number on the roll and in the average attendance is shown by increases of 12,379 and 5,000 respectively in the eleven years ending December 1899. Disregarding the fluctuations that have occurred during this period, the average attendance in the different islands shows a remarkable increase above that which obtained in 1889, being in 1899, 29 per cent. in Antigua, 108 per cent. in St. Kitts, 65 per cent. in Nevis, 112 per cent. in Dominica, and 112 per cent. in Montserrat. This increase is, of course, out of all proportion to any increase in the population.

The approximate cost per unit of average attendance is low as compared with that in other West Indian Colonies and it is matter for regret that the finances of the Colony do not permit of a higher expenditure. While in 1897 the expenditure per unit was 13*s.* 4*d.* it is now not more than 12*s.* 7*d.* In these figures are included grants to schools and training colleges and cost of administration. In Dominica, however, where all the schools are under the Government, the cost per unit is rather more than £1 per annum.

I should not fail to point out one beneficial result of that

provision of the Education Act of 1891 which requires private schools to be registered and their teachers certificated by the Inspector of schools. My predecessor thus refers, in his report for 1891, to the private-adventure schools: "The private schools are favoured mainly by parents anxious to evade the compulsory attendance of their children. The registers are unreliable and many attendances which have never been made are marked. Bad as is the accommodation of some of the public schools, it is as pleasure compared with pain to that of the private rooms. In one place forty children of ages ranging from three to fifteen were found crowded into a room 8ft. by 7ft. No less than ten of these 'schools' are held in bedrooms, and boys and girls are herded together in a most disgraceful manner. In one of these bedrooms the large four-poster served as a gallery on which were three classes, while two or three children were to be found under the bed, having been consigned to these lower regions for punishment." Such a state of affairs as described by Mr. Watkins cannot now exist, since all private schools are regularly visited and reported on by the educational district officers.

It is desirable to point out that while education is compulsory in the Leeward Islands Colony it is not, at least legally, in all the islands free. In Dominica and in Montserrat compensatory grants have been made to the schools in lieu of school fees; and in the other Presidencies, by force of the poverty-stricken condition of the people, fees are seldom paid. In 1899, the fees collected in Antigua, St Kitts, Nevis and in the Virgin Islands amounted to £130, and I anticipate that the fees collected in 1900 will show a great decrease from this sum. My predecessor recommended some years ago that fees should be abolished and grants made in lieu of them. This was never done except in the two islands already named, but it would appear, that on account of the circumstances of the people, few fees will in the near future be paid, and the schools will be poorer than formerly to the extent of some hundreds of pounds.

With regard to the average attendance at the schools of this Colony, it must be admitted that there is much room for improvement. In only one year, 1896, since the enforcement of compulsory education has the total average attendance risen above 50 per cent. of the number on roll. Perhaps there is no single reason to account for this low average attendance. It is certain, however, that both managers and teachers for the most part rely entirely upon the educational district officers for enforcing attendance without employing those means which are at their hand for ensuring regular attendance. Certain educational districts are very large and difficult to work by one officer, and people of the country districts resort to every device to evade the operation of the Law, for example, in many cases changing the names of their children. Again, the section in the principal Act which allows a parent to keep his child from school for reasonable cause, which may be illness or other unavoidable cause, is capable of a wide interpretation and is frequently very widely interpreted by the magistrates themselves. The extreme poverty among many of the people in

the sugar producing islands certainly acts adversely against any improvement in the average attendance, and there does not appear to be any immediate prospect that an improvement in this respect will take place.

Finally, to close this brief review of the working of the Education Acts in the Leeward Islands, I would point out that in my experience as an inspector of schools in another West Indian Colony I have observed in almost every school into which I have gone boys and girls of 12 to 15 sitting in the lowest standards with children of 5. With compulsory education such a state of affairs is impossible, and it must be reckoned among the benefits resulting from the enforcement of the Acts in the Leeward Islands that in the lowest standards we have children of almost equal ages, and similarly throughout all the standards. How great an advantage this result is to both children and teachers I need hardly point out. From my short experience of the enforcing of the compulsory Education Acts I have every reason to think that the introduction of this principle has been beneficial to the Colony, and I see no reason why it may not be enforced in other Colonies in the West Indies, especially in the towns of the larger islands.

DISCUSSION.

Mr. T. CAPPER (Superintending Inspector of Schools, Jamaica): I was unfortunately absent when Mr. Martin began his paper, and therefore I may be asking questions which are already answered. I should like to know the limits of age within which compulsory legislation is enforced in the Leeward Islands, and also what proportion of children within those limits was actually in attendance at the time when the attendance was at high-water mark.

Mr. MARTIN in reply to Mr. Capper: The compulsory age limits are from five to twelve years. There are no records to enable me to answer the second question, but I might mention that it is estimated that about ninety per cent. of the child population was on the school books.

In reply to questions from other members of the Conference: The average cost per head was reduced in 1898 to the figures stated because the finance of the Colony would not admit of a larger expenditure. With regard to the payment of fees in the case of parents who are unable to pay, there is a provision under the Law of 1890 requiring the school manager, on the certificate of the Government officer, to pay such fees. However, on account of lack of funds, that provision has only been enforced in two schools, so that practically the fees owed by parents who are unable to pay are never collected. The fees of the industrial schools are sixpence a week, and those of the elementary schools are a penny a week. Last year the amount of fees received was £130. Compulsory powers are

enforced all over the Colony. Except in Barbuda, where there is only one school, there are district educational officers in all the islands. The officer keeps a register of the children born in the district and when they are five years old he sees that they go to school. After leaving school the children follow the usual pursuits of people of their class.

The PRESIDENT: Mr. Martin's paper introduces a large and somewhat difficult question. Although compulsory attendance is provided for in many Colonies, it is only actually enforced at present in the Leeward Islands. Even there it is evident that the results are not wholly satisfactory. We must, however, recognise that on the success or failure of compulsory education hangs, also, the success or failure of agricultural education. We are indebted to Mr. Martin for his paper, and I trust that between this and the next Conference, the educational members will not only have discussed, but obtained a good general idea of what should be done to improve school attendance in these Colonies.

With your approval, I now propose that we form an Educational Section of the Conference, and that it now adjourn to the Council Chamber to discuss certain questions submitted for its consideration. His Lordship the Bishop will be Chairman, and Mr. Thomas Capper will be Secretary, of the Section. After the rising of the Conference, papers containing the questions and the provisional conclusions of the Section will be circulated, so that we may have ready by next Conference the general opinion of all the leading persons interested in the subject.

AGRICULTURAL CONFERENCE, 1901.

(CONTINUED.)

LEGISLATION TO CONTROL BUSH FIRES.

BY H. A. ALFORD NICHOLLS, C.M.G., M.D., F.L.S.

I have been asked to read a paper at this Conference on Bush fires and their harmfulness to the soil and to vegetation in those islands in which they are not controlled by legislative enactment.

The subject is one which has engaged attention for some years past and I have spoken and written a good deal about these fires and their harmful effects in those West Indian Colonies in which they are allowed to rage without interference. It follows, therefore, that most of what I have to say to you has been made public by me elsewhere in some form or other.

Now-a-days, however, it too often happens that useful legislation is delayed until its necessity is brought home to the Government and people by frequent discussions, by the reiteration of arguments, and by the constant statement of facts bearing on the subject. This, I hope, will be the last effort that will have to be made to bring about the much needed legislation to control bush fires, for I trust that the discussion which will follow the reading of my paper will crystallize the facts into such a concrete form as to allow the question to be dealt with satisfactorily by the various Governments concerned—the Imperial Department of Agriculture, of course, assisting by its advice and, if necessary, its initiative.

It may be well, perhaps, for me, in the first instance, to state briefly what steps have already been taken to bring the question before the public. In July, 1899, after a certain amount of discussion and correspondence, I raised a debate in the Legislative Council of Dominica on the destruction caused by bush fires in the island, by moving the following resolution:—

WHEREAS it is the custom during the dry season for peasants and others to clear lands by setting fire to dry grass and brush thereon;

WHEREAS in many instances such bush fires, having escaped control, have run on to cultivated and forest lands causing considerable destruction and entailing great loss to planters as well as interfering with the progress of the Presidency towards prosperity;

AND WHEREAS, such fires, by destroying seedling indigenous trees, prevent the reafforestation of the waste lands on the leeward side of the island thereby causing these lands to remain barren;

BE IT RESOLVED.—"That, in the opinion of this Council, it is desirable to empower the Governor by Legislative enactment to issue his proclamation in times of drought, forbidding, for certain periods, under severe penalties, the setting of fire on any lands whatever, unless in special instances permission in writing be given by an authorized official."

This motion gave rise to an interesting and instructive debate, during which the harmfulness of bush fires was borne testimony to by the Councillors, some of whom detailed the destruction worked by fire on their own properties. The resolution, I am glad to say, was passed unanimously by the Legislative Council, but the Government has not yet introduced a draft Ordinance to deal with the question. Afterwards, the West India Committee communicated with me on the subject, informing me that they had requested their correspondents in Antigua and St. Kitts to do what they could to get a similar resolution passed in the Legislature of those islands. Later on, the Governor of the Leeward Islands, in an address to the Antigua Council, pointed out the necessity of counteracting the evils caused by bush fires in the country districts; and there has been, I understand, some official correspondence on the subject with the Secretary of State for the Colonies. It had been decided that I should bring the matter before you at the last Conference, but I was unable to attend the meeting, and, as no definite action was taken by the local Government, I read a paper on the subject at a meeting of the Dominica Agricultural Society on May 30, last year, not only in order to keep the matter before the public mind but also to prepare the people for the promised legislation. This meeting was presided over by Mr. Bell, the Administrator of Dominica, who, during the discussion, admitted that I had "made out a good case for legislation." A similar resolution to that passed by the Legislature was then adopted by the Agricultural Society and a copy of it was subsequently forwarded to the Government. Such, then, is a brief account of what has been done in the Colony of the Leeward Islands towards the solution of the question, and I now bring the matter before this Conference. I understand however, that there are Representatives here from Colonies in which legislation to control the mischievous effects of bush fires has been in force for years, and I hope that these gentlemen will bring forward facts to show the usefulness of such legal restraint.

In the West Indies, and elsewhere in the tropics, under the generic term of Bush fires are included all those conflagrations, both great and small, whether caused purposely or accidentally, that destroy the vegetable products of the soil. They may be divided into five classes as follow:

1. The fires deliberately set to burn down plants growing on limited areas with the object of destroying blights that are troublesome or are likely to become epidemic.
2. The fires sometimes made to the windward of cultivated lands affected by insect blights, so that the dense smoke may kill or drive away the pest.
3. The "burns" when high forest is cut down, the trees lopped, and fire is used to destroy the immense encumbering mass of wood so as to render the ground sufficiently clear for cultivation.
4. The "grass fires" that are set in dry seasons to destroy dry rank grass in order to induce a new and tender undergrowth for the grazing of cattle or for the grass cutter's knife
5. The ordinary "bush fires" of Dominica and other mountainous countries, by means of which the soil is cheaply and expeditiously cleared of brush and weeds (cut down or hoed up) on lands intended to be put into cultivation.

The first class of fires is simply a method adopted in the treatment of diseased plants, and is one of the heroic remedies of the plant physician when he endeavours to stamp out a dangerous epidemic. Such a remedy, however, is never used without careful precautions being taken to prevent unnecessary damage.

The second class of fires differ from the first in that the cultivated plants are not destroyed. The plan is frequently employed in some countries to rid plants of insect pests which are readily killed by the acrid smoke of burning green wood, bush and leaves.

The third class of fires are seen only in forest clearings where they are made use of to remove the massive tangle of fallen trees that encumber the ground. In the early years of settlement in the West Indies, when the islands were covered with primaeval forests, these "burns" as they used to be and still are called, were part of the systematic work of all planters. Laborie, in his well-known work entitled *The Coffee Planter of Saint Domingo* published in 1797, gives particular directions as to the proper way in which the forest trees should be felled and the branches lopped and strewn, so as to get what he describes as a "good burn" that will clear the land sufficiently for commencing cultivation It is worthy of remark, however, that even this far-seeing writer, who penned his words over a century ago, deplored the destruction of certain constituents of the soil by those fires, and said "it is to be wished that burning could be dispensed with." Forest burns are now to be seen only in Dominica, St. Lucia, Trinidad, Jamaica and other islands in which there are still tracts of virgin forest; and, as such fires are essential and not fraught with dangerous con-

sequences, if due care be taken to prevent the conflagrations spreading, it is unnecessary further to consider them than to point out that legislation should not prohibit them, but should impose an obligation on the planter to prevent destruction of standing forest around the clearings.

The fourth class, or grass fires, are frequently seen in all the islands more especially in dry districts. As I shall later on have occasion to show, these fires—which often take place every dry season on the same ground--are disastrous in their ultimate effects, and the crop of fresh grass that springs up after them does not compensate for the evil worked.

The fifth class comprises the ordinary and well-known bush fires of the tropics. They are especially common in Dominica, and, in the dry season, they may be observed in that island in all directions. Indeed, not only the peasants but also many proprietors of large estates invariably employ this wasteful method of clearing land for cultivation. The advocates of the system say that the fire gets rid of the brush and weeds expeditiously and cheaply, and some say that it also does lasting good by destroying the harmful insects on the soil. It may be conceded at once that vegetable matter is removed most easily by fire and if the removal of this matter were the only consideration no voice could be raised against bush fires. But a serious question has to be answered in the first instance, namely, is this vegetable matter in the form of leaves and brush of so little use to the land and the planter that its destruction is desirable? And, following on this question is the equally important one, does the planter gain or lose by converting all his organic material into inorganic matter in the form of ashes? Both these questions I hope to answer in such a way as to show that the clearing of land by fire is the worst and most wasteful system that the planter could adopt. I would pause here, however, to say a few words about the erroneous idea that, in consequence of fire having been passed over the land, there is likely to be a long immunity from the depredations of insects for the reason that all of them have been destroyed in the burnt area. Now, most insects, like the higher animals in a state of nature, wander about in search of food. They are kept in check by natural laws, the chief of which is the struggle for existence. And it is futile to expect that a circumscribed area can be kept free from insects by passing fire over it, for, as soon as fresh vegetation springs up on the burnt land, the insects will find it out and come in from all sides, so that in a short time the insect population of the patch will be as numerous as it was before the fire was set.

The harmful effects of these bush fires on the soil may be thus tabulated :—

1. They destroy nitrogenous matters that would have gone to enrich the soil by the natural decay of the brush and leaves.
2. They destroy a certain proportion of the nitrogenous matters already in the upper layers of the soil.
3. They destroy the nitrifying microbes in the upper layers of the soil.

4. They sterilise the upper layers of the soil, and thus, for a time, prevent the fixation of nitrogen for the use of vegetation.

It may be roundly asserted that in all cultivated soils in the West Indies there is a deficiency of nitrogenous constituents, which deficiency is usually attempted to be made up by the application of manures or by the digging in of plants, more especially those of the pea family, grown on the land for the purpose. It is therefore most essential that the planter should do everything possible to add to his soil all the vegetable matter he can get hold of, so that, by its decay, it may increase the deficient nitrogenous constituents. And yet it is the custom in Dominica and elsewhere to destroy these most valuable organic materials by fire, instead of turning them into the land to repay the expense and labour of so doing over and over again by the resulting increased crops and finer produce. Indeed, as I have said elsewhere, "To prevent the peasant from destroying what is necessary for the fruitfulness of his land, is to do him good by ensuring larger crops from his holding. Thus it is advantageous to the country generally that this wasteful destruction by fire of important constituents of the soil should be put an end to." Agricultural chemists tell us that every pound of nitrogen in the soil has a definite value which may be expressed in figures. Were it possible to calculate the annual loss to planters on the basis of the money value of the nitrogen robbed from the soil by the bush fires, the total amount would be astounding.

But these bush fires not only destroy the vegetable matters intended by nature to enrich the soil, but they burn or bake the upper layers of the land, and this means that not only does the heat of the fire volatilize the nitrogenous matters already prepared in the soil for the assimilation of plants, but that it also destroys the nitrifying microbes that are constantly at work to produce the rich organic material for further plant food. Thus it seems that fires on lands, especially in these countries, are utterly disastrous in many ways, that they cause a diminution of the quantity of the produce got from the soil, and therefore deleteriously affect the fortunes of the planters and consequently the prosperity of the country.

To prohibit these fires entirely would be to prevent peasants and others from destroying what is necessary for the fruitfulness of the land and so it would be sound political economy. But political economy and "the liberty of the subject" are sometimes contradictory terms, as in this instance in which a man is held to have as much right to destroy the fruitfulness of a certain portion of the land as he has to pull down his house. But he must confine the destruction to his own property and not injure his neighbour's. Were these bush fires always limited to the circumscribed areas being cleared for cultivation there would be less to be said against them, and it is questionable whether, in the present state of public opinion repressive legislation could be suggested with any chance of its adoption. But by carelessness, by ignorance, and, sometimes, with malicious intent, the conflagrations spread over and ravage large

tracts of land, thereby destroying much valuable property.

The devastation caused by bush fires in Dominica alone is enormous, and it is undoubtedly a serious drag on the prosperity of the island. During the dry seasons the fires may be seen in all directions along the coast, in the valleys and on the hills The absence of all control has rendered the people quite reckless in regard to them. If a peasant has to clear a few square yards of land to plant some "ground provisions," he will set fire to the dry brush in the afternoon and then gaily go home without troubling as to where the fire may run to. A fire set in this way in Dominica, not very long ago, near to the sea, spread to neighbouring lands and produced a conflagration that raged for days, running up a wide valley, destroying everything in its path and then reaching and seriously damaging cane and lime plantations on the hills. Dominica planters will tell the tale of how their cacao and other plantations have been greatly injured and the crops ruined by fires carelessly set in contiguous peasants' holdings: and they will tell also how their woodlands have been destroyed by similar fires. Indeed the losses due to these constantly recurring fires have become so great that legislation is urgently needed. If the matter were carefully inquired into, it would be found that, year by year, an increasing extent of land is being rendered barren by bush fires. As an illustration of the correctness of this statement I may bring forward the following facts concerning certain districts along the leeward coast of Dominica. Many years ago there were thriving coffee plantations on these lands, but now they are barren wastes of rocks covered in places with a thin skin of soil. During the wet season rank grass and weeds spring up from seeds dropped by birds or blown by the wind. Were the land left to itself, by the operation of natural laws soil would accumulate and seedling trees would grow and increase in number and variety, and, in a comparatively short time in our West Indian climate, a "secondary forest" would result, and then, by the judicious felling of a portion of the wood, the land could be gradually brought back to cultivation. But what really happens is that most of these waste lands are subjected to the ravages of bush fires every year, the seedling trees are killed out and the soil is left burnt and bare with no live roots ramifying in all directions to hold its particles together, so that, when heavy rains come, the loosened surface soil is washed to the valley or sea, and nothing but a rocky barren waste remains. This disastrous destruction of a cultivable soil has been going on for years and years in many islands in the West Indies, and it has resulted in the conversion of former fertile districts into barren wastes in Dominica, Montserrat, Antigua and all the islands to the north. It has not only made deserts where there should be gardens, but it has actually in places produced a disastrous effect on the climate. Mr. Watts can tell you of the evil effects of bush fires at the northern end of Montserrat and throughout Antigua. And I doubt not that many here can bear testimony to the fact that I have not over-estimated the urgency of the question.

In Dominica there is a dry barren district known as the Grand Savannah, and, years ago, the late Dr. Imray endeavour-

ed to reclaim a portion of it by planting young Ceăra rubber trees on it in all directions. The plants grew well and there was every hope that this barren waste would have been brought into remunerative cultivation, and that a new industry would have been established in the country; but, unfortunately, the bush fires set by the peasants in the dry season swept over the plantation and killed out the rubber trees planted with so much care and expense. A similar attempt made later on to plant up portions of the Grand Savannah met with the same disappointing result, and it is clear that nothing can be done in Dominica to reclaim such barren lands until, by legislative enactments, the people are prevented from causing these extensive and disastrous conflagrations.

Legislation is also, undoubtedly, greatly needed in many of the other islands to abate the evils caused by these bush fires. It would not be advisable now to prohibit all fires on lands, but, without delay, an end should be put to the system whereby every person can, at any time, with impunity set fire to dry grass and brush and so produce a conflagration that may, and often does, cause great injury and loss to his neighbour's property, and that certainly retards the prosperity of the country. Although bush fires need not be prohibited altogether, they should not be allowed to be set in very dry seasons as they are then exceedingly dangerous; and, at other times, they should be so regulated that the evils I have brought to your notice may be mitigated if not entirely abolished.

DISCUSSION.

The PRESIDENT: Dr. Nicholls has placed before us an important subject in an able manner. In every tropical country with rank vegetation the regulation of the use of fire, especially during dry seasons, is essential to its agricultural progress. I had already furnished Dr. Nicholls with extracts from Laws in force in Ceylon, Mauritius, Cyprus and Jamaica.* We have therefore ample precedents for taking up the subject. It is within the experience of everyone present that great injury is done in these islands to the yearly diminishing forest areas as well as to cultivated lands by the careless use of fire. As guardian of large stretches of Government forest lands in Jamaica from 1879 to 1887, I was directly concerned in enforcing the provisions of the Law (25 Vic. cap. 30) "to protect Property from the careless use of Fire" in that Colony. The difficulty, I experienced then, was to detect the source of a fire and find out the person actually responsible for it. To solve this, I suggested in 1885 that every man who intended to set fire to his clearing, large or small, should be compelled to give notice, beforehand, to his neighboursand also at the nearest police station, so that if the fire escaped, the person responsible

* These and extracts from the Trinidad Law are given in the Appendix.

for it could be easily traced. I deprecate hasty action and would suggest that to-day we confine ourselves to facts within our observations and so convince those, who have not hitherto realised the injury done, of the necessity of preventing a continuance of it in the Colonies in which they are directly interested.

Mr. FAWCETT (Jamaica): As Dr. Nicholls has pointed out, there are a good many reasons which induce people to set fire to bush and grass lands, as in many cases is necessary. The question however is whether these fires cannot be so controlled as to do the minimum amount of harm and the maximum amount of good. In Jamaica hundreds of acres of good pasture land have been devastated and impoverished by the peasants setting fire to it in order to pasture their stock when the green grass springs up. In one district, proprietors have begun to fence in their land so as to prevent cattle from straying, and, in consequence, fires have diminished and young trees are springing up. The existing law in Jamaica has been enforced in the Blue Mountains to some extent, but, I do not think it is really of very much use, because, when a peasant rents an acre of land from the proprietor, he has to clear off the bush before he can cultivate his land, and the only way to get rid of that mass of vegetation is by burning. In most cases every precaution is taken to prevent the fire spreading to the neighbouring woodland, but, unfortunately, it often passes over the boundary line and considerable damage is done. In such cases the people have been brought before the magistrate and fined, with the result that they are now more cautious. There will however always be fires. In many cases, proprietors set fire to their own grass land to destroy the ticks, as this is, in their opinion, the only way of getting rid of these pests. In other cases when Guinea grass has been grazed and only the valueless part is left, the proprietors set fire to it. We have thought of legislation in connection with these bush and grass fires, but I think it will be difficult to formulate any scheme which will be generally applicable. Perhaps, if care were taken to see that the police regulations, already existing against the careless use of fire, were carried out, and the police insisted on notice being given by the peasantry and others when they were going to use fire, some good might result.

THE PRESIDENT: I should like to ask Mr. Fawcett whether specific instructions have been issued by the Government of Jamaica to protect the forest still existing in that Colony from injury by the careless use of fire on neighbouring areas?

Mr. FAWCETT: I do not know whether instructions have been issued of late, but in my opinion the Government should not allow any of their forest land to be let to tenants.

Mr. F. WATTS (Antigua): I am not sure that we have a sufficiently sound public opinion on this subject of forest and pasture fires in order to have useful legislation. I can support all that Dr. Nicholls has said with regard to the damage done by these fires in the West Indies generally. They would cease if those who are responsible for them recognised the loss they entail. I may refer to one form of bush and pasture fire which

is disastrous in Antigua. A great deal of the island, which was originally cultivated but is now abandoned, is covered with coarse pasture grass which is not eaten by the cattle after it has flowered and which is therefore useless. When burnt down, however, the new grass which springs up is eaten by the cattle, so that there is a distinct inducement offered to peasants and proprietors to fire the old grass in order to get pasturage for their cattle. On remonstrating with the people and showing them the great loss which ensues on the burning of large quantities of nitrogenous matters, they reply that they get the ash, and seem to be unaware of the fact that the ash would be always there. When knowledge on this question spreads, and we have a sound public opinion we shall very soon get legislation. But if legislation is imposed before public opinion is ready for it, there will be all sorts of grievances and all sorts of attempts to evade the law. Probably much more good will be achieved by thoroughly discussing and ventilating the subject. The matter is a very important one as it bears upon the question of the reafforesting of waste lands. This aspect of the question does not strike one in Antigua so forcibly as it does in St. Kitts and Montserrat, where the efforts made to reafforest the hill sides are thwarted by the grass fires of the dry season. Then there is the question of firing the grass in places like Jamaica to kill ticks, where it is said to be the only method of keeping the cattle free from these pests. I am not convinced of the efficacy of such fires and I should like to hear the arguments on the other side. I am confident that in Antigua the tick pest can be combated by other means than burning, but whether this is possible in the hilly country of Jamaica, I do not know.

Mr. SHARP (Jamaica): I have been struck by the remarks of Mr. Watts with regard to the tick pest. In Jamaica, not long ago, we obtained the services of a specialist, the late Professor Williams, to report on the tick pest there. Our experience is that we do not get rid of the tick by burning the grass. As soon as a grass field is set on fire, the female tick burrows into the ground and conceals herself among the roots of the grass. The fire passes over the field destroying what we call the grass lice, or young ticks, but it does not affect the female. The latter comes to the surface again and deposits her eggs. As soon as the grass is sufficiently high for the cattle to be turned into it, the ticks are there again. I have given much thought to the question of fires and I cannot discover any real necessity for using them. I can understand that in the cultivation of tobacco or cacao, there may be some excuse in using fire so as to get rid of pests and weeds cheaply, but when we compare the small profit with the serious damage done in instilling into the minds of the people the idea that the saving by burning is equal to the labour which would be expended in otherwise clearing the land, it is our duty to endeavour to stop the use of fires entirely. I know of no place where forest and other fires are more prevalent than in Jamaica. My experience leads to the conclusion that the only way to stop them is by legislation prohibiting their use or allowing them only under certain conditions, and on the recommenda-

tion of the proper authorities. To show that such legislation would be efficacious, I may mention that sometime ago, a serious fire, causing a considerable amount of damage, occurred on one of my plantations, the origin of which was traced to the carelessness of a man who had been cooking breakfast under one of the trees, the root of which took fire. I prosecuted this man for careless use of fire and he was convicted and sentenced to six weeks' imprisonment, the judge remarking that it was his intention to deal similarly with any person who was charged with a like offence The remarks of the judge had a very wholesome effect, and further notices were issued threatening prosecutions for the careless use of fire on plantations Thereupon the fires diminished in number and we passed through a severe drought without serious difficulty. I challenge any agriculturist or scientist to prove that there exists any necessity whatever for the use of fire in the cultivation of the ground, not only from a financial point of view but from that of improving the conditions around us. One effect of these forest fires in Jamaica has been to prevent certain proprietors from renting their land to tenants and consequently there are large areas that are not cultivated and from which the proprietors reap little or no benefit. I have had the advantage of living in various parts of Jamaica, and I must say that if there is a subject which requires urgent legislation and one which this Conference could usefully take in hand, it is the question of these fires. Personally, and on behalf of the Jamaica Agricultural Society, which I represent, I offer my congratulations to Dr. Nicholls for the very able and lucid manner in which he has dealt with this question.

Mr. Fawcett (Jamaica): Harm is done to a good cause when the argument is pushed too far. I am not certain if Dr. Nicholls has gone too far, but I am sure Mr. Sharp has when he states that fires are altogether unnecessary in cultivation. In reply to him I would point out that on certain clay soils in England, the grass is cut and burnt in heaps and the texture of the soil is thereby improved. Legislation is not a cure for every ill, and in this particular matter much depends on the people and especially on the large proprietors. I know of one proprietor who has gone to considerable expense in stopping the evil, and I feel sure that if the proprietors in woodland districts insisted on their tenants remaining on the already cleared lands, and prevented them from moving from place to place, the result would be beneficial.

Mr. Sharp (Jamaica): I am glad to find that Mr. Fawcett in replying to my remarks has confined himself to his experience in England.

Mr. Jordan (Montserrat): Bush fires are a serious matter in Montserrat. The island suffered severely from the hurricane of 1899, when nearly all the trees were blown down. Since then efforts have been made by the people to clear the mountainous districts, and I know of an instance where nearly a square mile of forest on the mountain side was destroyed by fire set by a peasant to clear an acre of rented land. The young growth from the trees which had been blown down by the

hurricane, was destroyed by this fire and during the rains the soil was washed down from the slopes. I have experienced great difficulty in persuading the peasantry to stop these fires as they say the ash is of value. I do not think *all* fires should be stopped, because in Montserrat this is the only means, for instance, of getting rid of Para grass. At the same time, I know that estate owners are anxious to stop forest fires, but the people will not rent land from them unless they are allowed to clear it by burning the fallen trees. I feel sure that if legislation on this question were adopted and enforced, the people would cease burning the forest.

MR. D. MCDONALD (Antigua): The able paper read by Dr. Nicholls is particularly interesting to us in Antigua where the subject of fires has been lately discussed. Sometime ago Mr. Watts read a paper on the subject to the Agricultural Society, when it was decided to discuss the paper later on with a view to eliciting an expression of public opinion preparatory to legislation. It will be evident therefore, how welcome any discussion at this Conference will be in Antigua, and how valuable will be the remarks of those members from other islands where legislation on bush fires already exists.

MR. HUDSON (St. Lucia): In St. Lucia the large proprietors are inclined to prohibit the use of fire entirely; but I do not think its use should be totally prohibited by legislation. In my opinion permission should be obtained from the proper authority and competent men might visit the localities where permission is asked for. The annual expense incurred would be from £100 to £200 which would be repaid by the saving effected. With regard to fires in clearings I can say, after fifteen years' experience, that it is absolutely necessary to burn forest land if cacao, coffee, limes or ginger are to be cultivated. I fully appreciate all the disadvantages attending the practice, but I have always found it necessary in clearing heavy forest growth.

MR. LOUIS BERT de LAMARRE (Trinidad): It would be much better if it were possible to do without using fire, but in places like Trinidad where cacao is cultivated, fires are considered necessary in first clearing the bush. Before fire can be used, however, a license has to be issued by the Warden of the district and security has to be given by the applicant by clearing a space, around the area to be burnt, twenty feet wide.

THE PRESIDENT: Very diversified opinions have been expressed on this important subject, showing that it requires further consideration. There appears to be a misconception as as to what is, and what is not, a legitimate use of fire in agricultural operations. In Jamaica the law referred to imposes penalties on the careless use of fire so long as it actually causes loss to property. The law is there, but it is perfectly useless unless enforced as instanced by Mr. Sharp. Forest lands belonging to absent, or careless resident, proprietors may still be burnt with impunity. On established plantations the injury, when it occurs, is more apparent and is usually dealt with. We come next to the use of fire in clearings for coffee, cacao, &c. If it could be managed, I should like to see the use of fire absolute-

ly prohibited; but where there is heavy tropical forest and where, after the trees are felled and lopped, there is a pile of vegetation several feet in depth covering the land, I fear it is impossible to get rid of this without the use of fire. But in all such cases the greatest precaution should be taken to prevent the fire from spreading. As in Trinidad, a license should be required beforehand (or due notice should be given to neighbouring proprietors and at the nearest police station as suggested at Jamaica), and in every instance an open space of, say, 20 or 30 feet be made all round the clearing. The periodical burning of pasture, or so-called waste lands, either by accident or design, is a ruinous process and every effort should be made to stop the practice. I trust that during the next twelve months members of the Conference will carefully study the subject, and also bring it before the local Agricultural Societies in order to have it thoroughly ventilated and ripened for future action. There is evidently a good deal to be done everywhere to guide and enlighten agriculturists in regard to the economical and judicious use of fire.

Dr. NICHOLLS (Dominica): There is one or two points I should like to clear up before the discussion is closed. Firstly, I would point out that both Mr. Hudson and Mr. Bert de Lamarre seem to have misapprehended or did not hear what I pointed out in my paper, that in clearing heavy virgin forest in the West Indies the only means of getting rid of the woody material is by fire. Unfortunately the fire destroys a good deal of nitrogenous matter but still there is no other means of getting rid of the fallen trees and débris. In Dominica a very large extent of forest land has recently been cleared in this way with the object of establishing a coffee plantation. I did not intend that the remarks made in my paper should apply either to Jamaica or Trinidad, because I understand there are laws in those Colonies by which the authors of injurious fires can be punished. With regard to the statement that public opinion is not ripe for legislation on this subject, I should like those who speak in this way to tell us what they mean by public opinion. In the islands where these fires are taking place, is there such a thing as public opinion? I can say that in Dominica the people are quite prepared for a law on this subject. It will, I believe, be quite sufficient if a law combining the provisions now in operation in Jamaica and Trinidad is passed and judiciously enforced in Dominica as well as in other parts of the West Indies.

APPENDIX.

The following extracts will illustrate the action taken in the Colonies mentioned in reference to regulating and controlling the use of fire:—

JAMAICA.

ACT 25 VICTORIA, CAP. 30.

An Act to protect Property from the careless use of Fire.

Be it enacted by the Governor, Legislative Council and Assembly of this Island, and it is hereby enacted by the authority of the same:

That any person who shall by the negligent use or management of fire in any place whatsoever, endanger any buildings, lands, cultivated plants, fences, or other property, or shall use or carry any lighted pipe, cigar, fire-stick, torch, or flambeau, whereby injury may or shall result to any buildings, lands, cultivated plants, fences or other property shall, on conviction thereof before any two or more Justices of the Peace of the parish or precinct where any such offence shall be committed, at the discretion of the said Justices, forfeit and pay a fine not exceeding ten pounds, together with costs, or be committed to the common gaol, or house of correction there to be imprisoned and kept to hard labour, for any term not exceeding ninety days.

MAURITIUS.

ORDINANCE NO. 13 OF 1875.

5. Any person who either wilfully or through his own negligence shall, by setting fire to herbs or grass, or by lighting a fire, cause a conflagration by which any trees or plantation of trees not belonging to such person or growing on any Reserves shall be destroyed, shall be liable to a fine not exceeding Fifty Pounds Sterling; reserving always to the Procureur General, should he think fit, the right to prosecute the offender under any other Law of the Colony.

Person burning trees on Reserves &c., to be liable to penalty.

CYPRUS.

ORDINANCE NO. 25 OF 1879.

An Ordinance for Amending the Laws relative to the Protection, Control and Management of the Forests in the Island.

Acts prohibited in Forests under the protection, control and management of the Government.

6. Whoever on such lands declared to be under the protection, control and management of the Government by notification issued under section 1, except with the authority in writing of the Commissioner of the District or of the Principal Forest Officer:-

(f) Sets fire to the Forest or kindles a fire without taking due precautions to prevent its spreading:

(g) Leaves burning any fire kindled within or in the vicinity of the Forest;

Shall be liable to a fine not exceeding £50, or to be imprisoned for a term not exceeding six months, or to both; and may be charged in addition such compensation for damages done to the Forest as the convicting court may direct to be paid.

CEYLON.

ORDINANCE NO. 10. OF 1885.

Enacted by the Governor of Ceylon, with the advice and consent of the Legislative Council thereof.

... Any person who—

Acts prohibited in such forests.

(b) sets fire to a reserved forest, or in contravention of any rules made by the Government Agent, kindles any fire or leaves any fire burning in such manner as to endanger the reserved forest, or any part thereof, or who, in a reserved forest—

(c) kindles, keeps or carries any fire except at such seasons and in such manner as a forest-officer, specially empowered in this behalf may from time to time notify,

(d) fells, girdles, lops, taps, or burns any tree,

shall be guilty of an offence and be liable to be punished with imprisonment for a term which may extend to six months or with fine which may amount to five hundred rupees, or with

both, in addition to such compensation for damage done to the forest as the convicting court may direct to be paid.

Such compensation when awarded shall be treated in all respects as a fine, shall be recoverable as such, and shall not exceed the amount of fine which such court has power to impose.

TRINIDAD.

ORDINANCE NO. 24 OF 1869.

An Ordinance for the Prevention of Accidents by Fire.

2. It shall be lawful for the Governor, by proclamation from time to time, to prohibit the setting of fire to land within such parts of the Island and within such times to be specified in such proclamation as the Governor may from time to time see fit : and any person who, after the publication of, and within the times specified in such proclamation, shall set fire to any land within any part of the Island mentioned in such proclamation, shall, on conviction thereof before a Stipendiary Justice of the Peace, forfeit such sum not exceeding fifty pounds nor less than five pounds, or be imprisoned for such term not exceeding six calendar months as to such Stipendiary Justice shall seem fit. Power to Governor to prohibit by proclamation the setting of fire to land.

3. Any person desirous of setting fire to any land shall give to the Warden of the ward within which such land may be situate a notice in writing specifying the local situation, extent, and abuttals of such land ; and such Warden shall inspect such land, or cause the same to be inspected by some competent person to be named by such Warden, and on such inspection being made, may, if he shall see fit, grant a license to set fire to such land, in which license shall be specified the days within which such license shall be in force : provided always that no such day shall be a day prohibited by any proclamation of the Governor. License to be obtained from the Warden before fire shall be set to land.

4. Before fire shall be set to any land under any such license, the owner shall cause an opening space of at least twenty-five feet in width to be cleared round the land, and all inflammable matter to be carefully removed from such space, and shall not less than three clear days before fire shall be set to such land, deliver or cause to be delivered to the Warden of the ward, a certi- Space to be cleared round land to be set on fire.

ficate under the hand of one householder at least resident in the neighbourhood, that such space has been cleared in the manner directed by this Ordinance, and that he has inspected the same, and the day when he has so inspected the same; and if any such certificate shall be false in any particular the person making the same shall, on conviction thereof before a Stipendiary Justice of the Peace, forfeit for every such offence a sum not exceeding fifty pounds nor less than five pounds.

Notice to police and to owners of adjoining lands.

5. Every owner of land in respect of which a license shall be granted under this Ordinance, shall three clear days at the least before fire shall be set to such land, serve or cause to be served on the police constable in charge of the police station nearest to such land, and on the owners of all lands adjoining the land in respect of which such license may be granted, a notice specifying the days of the week and month (not exceeding seven days at the most) within which it is intended to set fire to such land.

Service of notice.

6. Every such notice may be served on any owner by delivering the same to him in person, or by leaving the same at his residence on such adjoining land, with some person actually residing therein, or if there be no such residence, or no person can be found therein, then by affixing such notice on some open and conspicuous place upon such adjoining land.

Penalty for setting fire without license, &c.

7. If fire shall be set to any land without a sufficient license in that behalf under this Ordinance, or without such certificate having been delivered, or such notice having been given as hereinbefore required, the owner shall, on conviction thereof before a Stipendiary Justice of the Peace, forfeit for every such offence such sum not exceeding fifty pounds nor less than ten pounds as to such Justice shall seem fit. And every person not being the owner, who shall set fire or aid or assist in setting fire to such land shall, on conviction thereof before a Stipendiary Justice of the Peace, forfeit for every such offence a sum not exceeding ten pounds nor less than one pound.

Penalty for setting fire to Crown lands without sufficient authority.

11. Every person, who shall wilfully set fire to any Crown lands except by virtue of an Order in writing of the Warden of the ward within which such lands may be situate, to be made under the authority of this Ordinance, shall, on conviction thereof before a Stipendiary Justice of the Peace, forfeit a sum not exceeding fifty pounds nor less than five pounds, or to be imprisoned with or without hard labour for any

term not exceeding six calendar months, as to the convicting Justice shall seem fit.

12. It shall be lawful for the Warden of any ward within which any Crown lands may be situate, by an Order in writing, under his hand, to make order for the setting of fire to any such land on any day not being a day prohibited by any proclamation of the Governor; and public notice of such Order having been made shall be given by affixing copies of such Order in some open and conspicuous part of the several police offices within the several wards within which such land or any part thereof may be situate, at least ten clear days before the first day to be appointed in or by such Order for setting fire to such land: provided always that no such Order for the setting fire to any Crown lands shall be made in any case where the sub-intendant of Crown lands shall prohibit the making thereof.

Power to Warden to make order for setting of fire to Crown lands.

Proviso.

13. Every person, who shall carry any lighted torch or other matter in a state of ignition, not sufficiently enclosed so as to prevent danger from fire in or upon any high road or any Crown lands shall, on conviction thereof before a Stipendiary Justice of the Peace, forfeit for every such offence a sum not exceeding five pounds.

Prohibition against carrying lighted torch, &c., on high road adjoining any plantation.

14. Every person who shall smoke upon any plantation save and except within a dwelling-house or shall carry any lighted torch or other matter in a state of ignition not sufficiently enclosed so as to prevent danger from fire upon any plantation shall, on conviction thereof before any Stipendiary Justice of the Peace, forfeit for every such offence any sum not exceeding five pounds.

Prohibition against smoking, &c., on plantation.

15. It shall be lawful for the Warden of any ward, within which a fire may take place, or if there be no Warden present at such fire, then for any Stipendiary or other Justice of the Peace to call upon and require every male person present at such fire to be aiding and assisting in the extinction of such fire; and any such person who after being so required, shall refuse or fail to be aiding or assisting in such manner as such Warden or Justice of the Peace may direct, shall on conviction thereof before a Stipendiary Justice of the Peace, forfeit such sum not exceeding five pounds, as to the convicting Justice shall seem fit, unless he shall prove to the satisfaction of such Justice, that at the time of such fire he was under the age of fourteen years,

Warden may require every male person present at a fire to aid in its extinction.

or above the age of sixty years, or was prevented from bodily sickness or infirmity from being so aiding and assisting.

Recovery and appropriation of penalties.

18. All penalties and forfeitures under Clause 11 of the Ordinance may be sued for and recovered on the information of the owner of the plantation or land on which the offence shall have been committed and shall be paid to such owner; and all other penalties and forfeitures under this Ordinance shall or may be sued for and recovered on the information of any person, who will sue for the same and shall be paid one moiety thereof to the Warden of the ward, within which the offence shall have been committed, for the use of the ward, and the other moiety to the person who shall inform and sue for the same.

THE TREATMENT OF SOILS IN "ORCHARD" CULTIVATION IN THE TROPICS.

BY THE HON'BLE FRANCIS WATTS, F.I.C., F.C.S.

Government Analytical and Agricultural Chemist to the Leeward Islands.

With the extension of the cultivation of such crops as limes, oranges, cacao and coffee in the West Indies, problems concerning the treatment of soils in orchards are constantly arising, some of which are not altogether easy to solve. One of them is how can the mechanical condition or tilth of the soils of old orchards be maintained? There is room for considerable difference of opinion on this point and it appears to me to be one which may be discussed with advantage at a Conference such as this.

The common practice in the West Indies is to establish lime, orange, or cacao orchards by planting the trees in selected spots which are cultivated for some years, and crops of tannias, yams, cassava, and sweet potatos are reaped for several seasons, before the fruit trees attain any considerable size. This plan is a good one, as it is economical and leaves the land in good tilth. When, however, the fruit trees have attained such a size as to necessitate a cessation of the raising of intermediate crops, the question arises as to the course to be followed then. I have observed several plans in practice. In a few cases the land has been allowed to become covered with grass between the trees, and cattle have been pastured upon it, a plan which appears to be unwise and disastrous. In other cases attempts have been made to maintain a certain amount of cultivation by forking the land between the trees, or by breaking up the surface with a mattock, or by weeding and consequently stirring the surface soil with the hoe.

The attempt to maintain and develop an orchard and, at the same time, to pasture cattle between the trees, is abandoned by most people now, although it was at one time adopted on a fairly large scale. The cattle damage the trees, and, in wet weather, tread the soil into a compact mass, thereby diminishing its friability and consequent fertility.

Forking between the trees is possible until their branches and roots have thoroughly occupied the space allotted to them. While this work is useful, if carefully done, both branches and roots may be injured unless great care is taken. In situations where the soil is rich and moist, the root-pruning involved in a thorough forking may check a good development of blossom and fruit, while in dry and less fertile situations the result may be most injurious.

I am inclined to think that weeding with the hoe has been of doubtful utility. The weeds are cut down but the condition of the surface is often impaired a hard, hot, compact surface commonly resulting, especially in poor, dry situations. There is also a tendency to draw away the soil from the trees, and thus to sink them in saucer-like hollows.

In places, where moisture is abundant and the growth of weeds luxuriant it is a common practice to cut down the rank grass and weeds, with a cutlass, leaving the soil untilled. This imperfect method of keeping the land in order is usually explained as due to the difficulty of procuring field-hands for the work, or because the financial position dictates a limited expenditure. Observation has led me to think that this method does not need an apologetic attitude, but that it has a good deal to recommend it, and that, under some circumstances, it may be the best possible. By such a method, the soil, though quite untilled by implements, remains in a good state of tilth, the roots of the weeds which are killed, when the plants are cut down or die naturally, form air spaces reaching to a considerable depth in the soil, and the earthworms, usually present in abundance in places thus treated, are active agricultural allies. The weeds spread over the surface form an excellent mulch, conserving moisture and adding steadily to the store of humus. Indeed, by such a method, we approach very nearly to the natural conditions prevailing in a coppice or young forest, where experience teaches us, we have the conditions which go to the formation of virgin soil. Some time ago my attention was drawn to this phase of the question by Mr. A. D. Lockhart, of Geneva, Dominica, who showed me many acres of lime orchard, which had been planted amongst sugar-cane when that crop was about to be abandoned, and which has subsequently remained absolutely untilled, the rank grass and weeds being periodically cut down with a cutlass and spread as a mulch over the soil. The physical condition of the soil was excellent, and there appeared to be no need whatever for mechanical tillage. Further observations, of places similarly treated, have convinced me that this method may be safely adopted in such districts as have an abundant rainfall, but how far it would be successful in a dry district I cannot say. The economy of the method is obvious, and at once commends itself

to the notice of planters in districts where the rainfall is abundant and the supply of labour scanty.

In practice then, it would seem desirable to establish young orchards in the midst of other crops,—such as sugar-cane and 'provisions'—due regard, of course, being paid to the needs of the young fruit trees. As soon as the cultivation of intermediate crops has ceased the fork may be used for a short period, but, as soon as the roots of the young trees begin to fully occupy the soil. all tillage must cease and the periodical cutting down of the grass and other weeds commenced. In this way the soil becomes fitted for the undisturbed development of the fine roots of the trees, the periodical mulching maintains a favourable surface condition, and the fine roots near the surface, which are protected by the mulch, bind the soil together and thus prevent loss by washing during heavy rains.

Perhaps nature may be aided by controlling, to some extent, the character of the undergrowth for periodical cutting, and one naturally turns to the introduction of leguminous plants. Many leguminous plants will be present amongst the other weeds, and I would suggest that experiments be tried in the way of growing native or introduced plants of this order, provided they possess no features which would make them objectionable, in orchards. I have, for example, seen pigeon-peas (*Cajanus indicus*) used with excellent results amongst young lime trees, and I have suggested that *Cassia occidentalis*,* or some of its allies, might be found useful in this connection. I understand that experiments are in progress with these and other plants such as cow-peas and woolly pyrol.

In devising methods of dealing with orchard soils, I think we are liable to be misled, to some extent, by the fact that our ideas are largely based upon the methods followed in arable culture, many of which deal with matters other than the mere tilling of the soil, like sowing and weeding, which are of little importance in orchards. It is desirable that we should look at the question from a fresh point of view, and it is with the hope of promoting discussion and exchange of opinions on an important subject that I bring forward these brief notes to-day.

DISCUSSION.

Mr. HART (Trinidad): The subject of Mr. Watts' paper is one of considerable importance to planters in the West Indies. In Nicaragua, where cacao has been cultivated for a number of years, the trees are planted in straight rows with an interval between each row, and the weeds are allowed to grow to a certain extent for some seasons, after which they are cut down and buried in alternate rows.

* A shrubby plant, three or four feet high, with yellow flowers; known as wild coffee, French guava, stinking bush, *casse puant* amongst other names. [ED. W. I. B.]

Dr. Nicholls (Dominica): The system of orchard cultivation recommended by Mr. Watts is the one which has been in use in Dominica and elsewhere for a long time. It is found in Dominica that the most economical method is to hoe the weeds, except on sloping lands where the weeds and shrubs are cut down with a cutlass and the roots are left in the soil so as to prevent its being washed away by heavy rains. The cut leaves and branches are used as a mulch. I understand, however, that in the lime cultivation, hoeing is not considered advantageous, and I may mention that in Montserrat, while the hoe was used, the lime plantations gave small crops, and, in some instances, the whole cultivation died out. Whether the hoeing of the soil was the sole cause of failure it is impossible to say.

Mr. Fawcett (Jamaica): The treatment of the soil in orchard cultivation is a very complex problem, and I am pleased indeed to see that Mr. Watts has only applied his recommendations to one particular set of conditions. The most important thing in the tropics to guard against is, in my opinion, the exposure of the soil to the direct rays of the sun, which causes great injury both to the soil and the crops growing thereon. I was very much interested in this question in starting an orange grove in the Blue Mountains in Jamaica where I had to consider the question of the washing of the soil on the sides of slopes and also that of covering the soil with some mulch. I came to the conclusion that it was better to leave, temporarily, the ground between the trees in weeds, and, gradually, to substitute various leguminous plants.

The President: In bringing this discussion to a close it is desirable to point out that the cultivation and treatment of permanent plantations, and the production of remunerative crops is one of those practical matters that have to be dealt with strictly in accordance with local conditions. On very steep slopes, cutting down weeds with a cutlass and using the débris for mulching and terracing purposes would no doubt be a good plan. On easy slopes, I would recommend light forking to enable the rains to soak into the land, and carefully graded "contour" drains to prevent wash and loss of soil. The soil found in the drains should afterwards be thrown back on the land. On flat lands, fewer drains would be necessary ; but here again I would still fork the soil so as to render it permeable to rain and to keep it cool and moist. I must candidly confess that the proposal to allow weeds, and especially grass, to grow — to any extent—amongst cacao, coffee, &c.. is one that has greatly surprised me. I believe a large number of coffee plantations in the Blue Mountains in Jamaica have been ruined by such a plan. I am not in favour of allowing grass to grow in regular plantations under any circumstances. What we require in the comparatively small areas under crops in these islands is an intensified or practically "garden" cultivation so that we obtain the largest possible returns from a limited acreage. I would prefer, when coffee or other trees do not cover the land, to follow the recommendation made by Mr. Fawcett and to cultivate leguminous plants. These are in every way preferable to grass as they could afterwards be dug into the soil to enrich it with humus and nitrogen.

RUBBER PLANTING IN THE WEST INDIES.

BY J. H. HART, F.L.S.

Superintendent, Royal Botanic Gardens, Trinidad.

The cultivation of rubber-yielding plants, as a profitable industry, has attracted considerable attention among West Indian planters during the past decade. This is due to several causes, the most important of which is the steady rise in price of the raw material, and the increasing number of uses to which it is applied.

In commencing the cultivation of rubber-yielding plants, the tropical cultivator has to ask himself many serious questions. The venture is new, and there is but little previous experience to guide him. Some of the principal points he has to consider are as follows:—(1) Will rubber trees thrive in the West Indies? (2) Which is the best kind to grow? (3) How much per acre will it cost to establish? (4) Which is the best method of planting? (5) What are the difficulties of harvesting and marketing the produce? (6) What yield may be expected? These questions might be greatly extended, but if answers are given to the above, based upon actual fact, observation and experience, it may assist the intending planter to come to some conclusion as to whether the industry is likely to turn out profitably or otherwise. The endeavour in this paper will be to afford answers from the point of view of an observer, disinterested as regards financial matters, but interested professionally in any development of new industries which tend to the public benefit.

Thanks to the kindness of the parent establishment at Kew, the chief West Indian Botanic Establishments were, many years ago, furnished with plants of the best known kinds of rubber-producers. The exact date at which the first were received is not shown by the Trinidad records, but, judging from the size and rate of growth of the trees and assisted by the memories of old employees, it is estimated at some twenty five or thirty years ago. The date can probably be supplied by the Kew records. The most important rubber-plants which have been introduced into Trinidad are:—The Central American rubber tree (*Castilloa elastica*, Cerv.); the Para rubber tree (*Hevea brasiliensis*, Muell.); the Ceara rubber tree (*Manihot Glaziovii*, Muell.); the East Indian or Assam rubber tree (*Ficus elastica*, Roxb.); several species of African rubber vines (*Landolphia*); and the West African or Lagos silk rubber tree (*Funtumia elastica*, Stapf. = Kickxia africana, *Benth.*).

A paper on rubber in Trinidad should not omit mention of our native or indigenous Balata, the produce of *Mimusops globosa*, Gaertn. This product, however, can hardly be classed with the produce of trees already mentioned, but rather with the guttas. Balata trees are common in the Trinidad forests and could be very largely cultivated at small expense, but the growth of the trees to a productive size requires too many years for them to be readily taken up for general cultivation.

As, however, this tree provides one of the very best and most lasting timbers for tropical use, and one always in demand for railway sleepers and building purposes it may be, that it could be cultivated as a timber tree, and the production of Balata considered as subsidiary

It is now proposed to discuss the size and growth of the introduced trees, and in doing so I shall answer the questions put by the planters, commencing with the first: Will rubber trees thrive in the West Indies? Taking them in their order of arrangement we have first the Central American rubber tree.

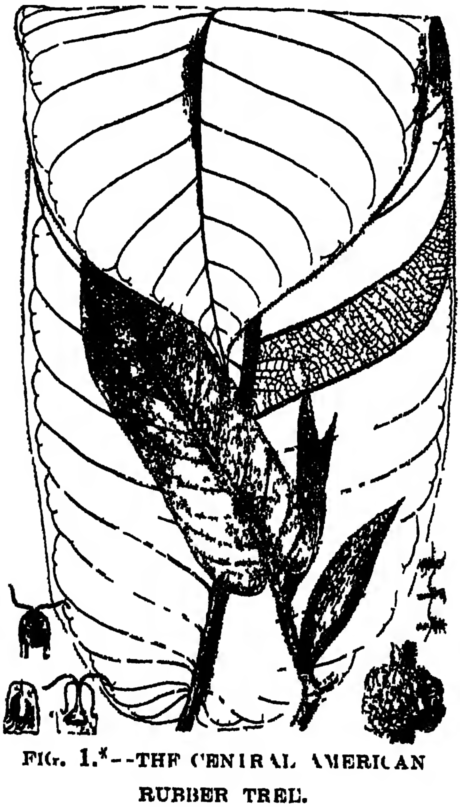


FIG. 1.*--THE CENTRAL AMERICAN RUBBER TREE.

(*Castilloa elastica*, Cervantes.)

One mature leaf and a terminal leaf-shoot,—one-third natural size. (1) Group of female flowers, or pistillate receptacle; (2) a single female flower with exserted filiform stigmas, usually two but rarely three; (3) and (4) sections of ditto. showing the ovary in different stages of development; (5) magnified portion of margin of leaf showing stiff bunches of hair.

This is a native of Central and some parts of South America. The writer has met it growing wild in Veragua, Panama, and in Nicaragua, where the trees attain a large size. The largest tree in Trinidad is over seventy-five feet high, and has a girth of six feet at three feet from the ground. Others planted in 1886 are fifty-eight and sixty inches in girth. Another tree planted in 1888 measures forty feet in height and fifty-five inches in girth at three feet from the ground, having increased four inches in diameter during the last year. These trees produce quantities of good seed yearly from April to June, and sometimes small crops at other times of the year. In the Annual Report of the Botanic Department, Trinidad, for 1899, it was stated that in a small field planted at the new Experiment Station in July 1898, some of the trees were, in December

* The figures illustrating this article are reproduced from the *Cantor Lectures on the Plants yielding Commercial India Rubber*, delivered before the Society of Arts by Dr. Morris on April 18, and 25, 1898.

1899, eleven feet in height. At the time of writing this paper, (twelve months later) the best five of these trees were found to average nearly eighteen feet in height and twelve inches in girth, whilst last year their girth was between six and seven inches. These trees are not planted on rich ground; on the contrary, they are growing on part of an abandoned sugar estate and the land is poor in quality but fairly well drained and shaded. The trees have received no special cultivation. In another part of the establishment is a set of trees planted out under shade. The average height of these trees is not more than eight feet, although planted before those at the Experiment Station. Some years ago a planter in Tobago and several in Trinidad planted seedling *Castilloas* purchased from our nurseries. These were planted out under widely varying conditions, but, nevertheless, they have all grown well, and from some of these plantations a large exportation of seed has been made which has realized good prices. Captain Short, the owner of the Tobago property, has published in the Ceylon *Tropical Agriculturist* an account giving some details of his experiment and the result appears highly favourable. His letter is printed as an appendix to the present paper. In Trinidad, we have now no less than eight private plantations of considerable extent, and recently a company has acquired land for the purpose of carrying out extensive operations.

One of our largest trees has been tested by tapping and yielded 2·14lbs. (avoir.) of rubber-fluids and ·69lbs. (avoir.) or thirty-two per cent. of clean rubber. From these rubber-fluids the specimen of rubber I now exhibit was produced. It is of excellent quality and is estimated to be worth three shillings a pound. It being found desirable to estimate the quality of the rubber produced by younger trees, a small quantity of rubber-fluid was taken from the new plantation previously mentioned. This yielded twenty-five per cent. of rubber, but it is hard, brittle and altogether of a very inferior quality, as may be seen from the specimen in my hand. This experiment would appear to dispose of the possibility of good rubber being made from young trees, unless some means can be found for rendering the material so obtained of better quality. Some eight per cent. of rubber is reported to have been obtained from the dry material of a young stem, but unless such rubber can be produced of good quality, it is clear that it is useless to attempt extraction. Trees of eight years old and upwards have been proved to produce good rubber, and possibly some little may be obtained earlier where the trees are in land which tends to hasten their maturity. The bleeding of *Castilloa* trees by light wounds is tedious and expensive work and can only be economically performed on large trees when planted closely together. From the above it will be seen that the Central American rubber tree is well established in Trinidad. In order to render its cultivation remunerative, I am of opinion that it will be necessary to cultivate it on large areas, by itself, and not to form scattered or mixed cultivations. The seed of *Castilloa* has a very fugitive vitality, and special packing is required to transport it to any considerable distance.

FIG. 2.—THE CENTRAL AMERICAN RUBBER TREE.

A tree about ten years old, growing in British Honduras (from a photograph taken by Mr. E. D. M. Hooper, of the Indian Forest Department.) The spiral cuts on the stem illustrate the manner in which the trees are tapped. On the extreme left may be noticed the vertical gutter connecting the transverse cuts and conveying the milk to the base of the tree. The tree represented is growing on the edge of a forest in a clearing amongst bananas, coffee, and other tropical plants.

Once ripe it must never be allowed to get dry, or its germinative power will be destroyed. Many thousands of plants and seeds have been distributed to local planters from our nurseries.

The Para rubber tree (*Hevea brasiliensis*) grows freely at the Botanic Gardens. It was at one time thought that Pará rubber would only thrive on lands which are liable to periodical inundation. In Ceylon, the tree has been found to do best on fairly flat land, at about sea-level, with good alluvial soil, and in Trinidad the trees are even growing on a dry and gravelly soil. Our largest tree of this species has a stem over five feet in girth and fifty feet in height and is supposed to be twenty-five years old. Rubber is freely produced and what has been made is of excellent quality, and appears to keep better than any other kind. Specimens are exhibited which were made some three years ago as well as freshly made specimens. It is a well known fact that rubber goods rot very quickly in the tropics, especially tubing and hose, but it is fairly certain that if made of Para rubber their length of life would be much extended. Central American rubber, on the other hand, kept for the same length of time, becomes soft and sticky however well prepared, and no time should be lost in despatching it to market in cool climates.

FIG. 3.—BRANCH OF PARA RUBBER TREE.

(*Hevea brasiliensis*, Muell.).

Showing trifoliate leaves and numerous small flowers. The female flowers are larger and terminal. The capsule (7) is cut open to show position of the seeds, usually three in number. Seed (8) is one half natural size.

Para rubber may be taken from the trees at less expense than Central American, as all that is needed is slightly to wound the tree and collect the spontaneously coagulated rubber some twenty-four hours afterwards, rolling it into balls like the specimens exhibited. I estimate from my experiments that a man could easily collect three or four pounds per day by this method, if the trees were growing closely together. In places where the roots of *Hevea* become exposed a large quantity of rubber can be extracted from them. Young trees of *Hevea* planted at the Experiment Station in July 1898, now show an average of six and a half inches in girth three feet from the ground and most of them are over eighteen feet in height. From the largest of our trees several

FIG. 4.—TAPPING TREES OF HEVEA BRASILIENSIS.

The rugged, gnarled appearance of the stem is due to successive tappings causing thickening of the bark.

crops of good seed have been harvested which have given us sufficient plants to meet present demands. A large area situated in the valley of one of the largest rivers in Trinidad, and really a counter-part of the valleys in the delta of the Orinoco where *Hevea* flourishes, is now being planted with this tree by an experienced traveller and botanist who has spent much time in the *Hevea* forests of the South American Continent. A variety has been introduced into the Experiment Station which is stated to thrive in dry localities as it was found on the mountain sides of the upper reaches of the Orinoco. The seed of this variety is not more than one-half the size of that of home-grown *Hevea brasiliensis*. Several

trees of *Hevea confusa*, Hemsley, are growing in the old gardens, but their rubber is yellow and sticky, and does not appear to be worth much at present, but it is possible that the material may improve with the age of the tree as in the Central American rubber tree.

Ceãra rubber, the produce of *Manihot Glaziovii*, a native of north-east Brazil, comes next on our list. This tree thrives well in some districts in Trinidad, but is only suitable for dry hill-sides or mountain lands. It does not succeed on flat alluvial soils, especially those with underground water. Some trees were planted a few years ago at the Convict Depôt, Chaguanas, but these lands have now been sold to settlers. The trees when last seen were about twelve or fourteen feet high, and some six inches in diameter. In their best days but very little rubber was obtainable from them. A tree exists in the Botanic Gardens which is thought to have been planted out about the same time as the *Heveas* and *Castilloas*, that is, some twenty-five years ago. It is now about twenty feet high and has a stem diameter of some eight inches. A few trees planted at the St. Clair Experiment Station in 1898 are now about ten feet in height with a stem diameter of three inches. From these trees rubber-fluids were obtained which gave small specimens of fairly good rubber, although the trees were but two years old. It is reported on good authority that on a private plantation Ceãra trees have made twice as much growth as at the station. The situation on which they are growing is warm and sheltered hillside land. There is good evidence that this tree commonly makes quick growth in its younger stages but increases very slowly after arriving at a certain size.

The fourth kind of rubber on our list is East Indian or Assam rubber the produce of *Ficus elastica*. This is a well-known tree, but the amount of rubber to be obtained from it under existing conditions is small when compared with other kinds, and it is therefore unlikely to be taken up for extended cultivation in the West Indies.

Fifth on our list come the West African rubber vines, under which general name are included several species of *Landolphia*. Being climbing plants or *lianes* they generally depend for their support on trees and, in consequence of their habit, it is doubtful whether they will ever be suitable for cultivation on a large scale. It is possible, however, that they might, with some advantage, be planted on lands of little value. The rubber produced by some of these vines is of excellent quality and keeps well. There is no trouble with the coagulation of the rubber-fluids of these plants as they harden as they exude, from the wounds.

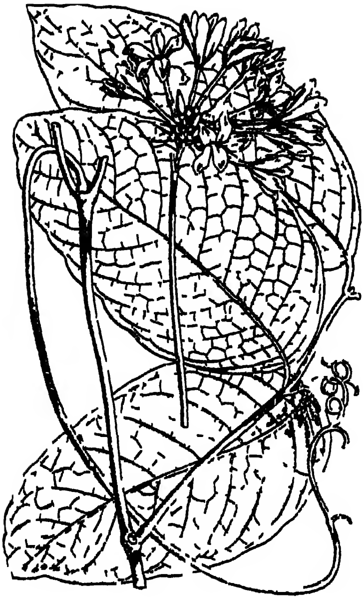


FIG. 5.—WEST AFRICAN RUBBER VINE.

(*Landolphia florida*, Benth.)

Portion of shoot showing tendrils and leaves. Also a panicle of the sweet jasmine like flowers.

FIG. 6—WHITE RUBBER VINE OF WEST AFRICA.

(*Landolphia owariensis*, Beauv.)

(1.) Flower.
(2.) Section of Flower.
(3.) Stigma.
(4.) Fruit.

West African, the, or Lagos silk rubber, is the next to demand attention It is a comparatively recent introduction from the West Coast of Africa and is the produce of a tree now known as *Funtumia elastica*, Stapf., formerly known under the name of Kickxia africana, *Benth.* For our first supply of seed we are indebted to the Royal Gardens, Kew, but later consignments have been received direct from Lagos Plants, put out in one of the trial sections at St. Clair in July 1898, now average thirteen and a half feet in height, and have a stem circumference of seven inches They are growing freely and look as if they would speedily make large trees. Mr. Millen of Tobago, who has been in the native forests of this plant, reports it as being a large forest tree. The St. Clair trees have already flowered and produced seed, and a large number of plants are now on hand in the nurseries grown from our first crop. Even at their present early age of three years these trees bleed freely, but are not yet of sufficient size to base any reliable estimates as to yield or value. The specimen exhibited, taken from our own trees, shows however that, even now, the rubber-fluids give manufactured material of excellent quality. It is always injudicious to hazard a prophecy as regards a new introduction, but, as far as our experience goes, this rubber tree has many points to recommend it, and will probably take a leading place among those species worthy of the attention of the cultivator. If a demand arises there will be little difficulty in supplying plants as a large stock can easily be raised from home grown seed. The rubber keeps well and appears to stand near to good Para in value. A point which will recommend it to some is the fact that although it certainly grows faster under shade, it can make good growth when fully exposed to the sun.

To attempt to treat of all the rubber-producing plants would take too long, and be out of place at this Conference where the time at our disposal is so short, neither would it be of any benefit to discuss the kinds which inhabit climates very different from that of the West Indies, where it is unlikely that any of them would thrive. There is however a very fair choice in the kinds I have mentioned, since in the Central American rubber tree we have a plant suitable for plains at low elevation; in the Pará rubber tree a plant for swampy districts; in Ceàra rubber a plant for poor and dry lands and hillsides; in the Assam rubber tree a plant that appears almost ubiquitous; in the West African rubber tree a plant adapted to poor dry soil at low levels: while in the West African rubber vines we have plants which might be made to cover rocky or other uncultivable ground.

The first question: Will rubber trees thrive in the West Indies? has, I submit, been fairly answered in the affirmative as far as Trinidad is concerned; but I wish it to be distinctly understood that no one should assume that the same plants will thrive in other places with the same facility as they do there. With, however, a locality, soil, exposure, protection and humidity similar to Trinidad there appears no reason why they should not flourish in other West Indian islands also.

The second question, as to the best kind to grow, can only

be answered fully when the locality, soil, aspect, &c., is well known. The Central American rubber tree appears to be one of the best for general cultivation, as it grows fast, gives quick returns, and affords a large yield; but it is clear that all the surrounding conditions must be well studied before it can be decided which is the best plant for any particular locality. Para rubber takes longer to grow, but may, in the end, prove more profitable than Central American.

The third question, that of the cost of establishing, is, like the second, one which depends in the main on the situation and local circumstances, as supply of labour, &c. No one could say what it would cost to plant up a certain estate in rubber trees if the locality were strange to him, and even if familiar, an estimate would still be difficult. The experiments at St. Clair are not a safe guide, for the varying conditions of our work make it impossible for us to deal with land on the same terms as on a private estate, and, moreover, the area dealt with is too small to afford reliable data. The cost of planting can therefore only be approximately estimated, but, it is fairly clear, that it should not cost so much as for cacao which is known to range from £12 to £15 per acre. From our experience it is estimated that not more than one-half these amounts would be required.

The next question is, What is the best method of planting? Now in the case of cacao there are certain established rules to guide the planter. In planting rubber, however, we have plants to deal with which produce their crop in an entirely different manner from cacao, and it is evident that clean and straight stems are absolutely necessary to facilitate economy in the operation of extracting the rubber-fluids. To obtain straight stems there is no better method than close planting and then thinning out, by degrees, the weaker trees until a permanent set of trees at proper distances is obtained. No pruning can ever secure straight stems in the same way as close planting, and it is false economy to plant at wide distances, as by that method the trees will grow very bushy and be unsuitable for the ready extraction of rubber. The actual method of planting or placing rubber plants in the ground is the same as for any other plant and the chief care to be taken is to see that they are not planted too deeply in the soil.

The next point the planter enquires about is harvesting his crop. There is much to be learned in this respect, for hitherto the methods have been crude in the extreme, but at the same time no insuperable difficulties have presented themselves. There can be no doubt that, as private estates come into operation, better and more economical methods will be discovered, and so far as the question has been studied in Trinidad, little difficulty is to be anticipated.

The rubber-fluids, latex or milk of *Castilloa*, can be readily coagulated in several different ways. The sand filter is probably the simplest method and the creaming process comes next. The globules of rubber being lighter than the other materials with which they are mixed, separate easily by the use of centrifugal machines of the type of the Babcock milk tester.

The sixth question, or that on the yield to be expected, cannot be fully answered, as the records of experiments in this direction are far from complete. Our trials show, however, that at least half a pound of dry rubber can be taken at one time from a single tree of *Castilloa*, without affecting the seed-bearing powers of the tree. Trees of *Hevea brasiliensis*, still more carefully treated and operated on within easy reach of the hand when standing on the ground, have given a gross weight of 2·26 lb of rubber, the major portion of which, weighing 15·8 ounces, is of excellent quality, as can be seen from the specimen exhibited.

Owing to the limited number of trees at our disposal, and on account of our anxiety to do nothing to spoil their seed-producing powers in consequence of the demand for seed and seedlings, I have hitherto refrained from conducting a regular series of experiments in extraction, but I hope to be able soon to organize a set of experiments which will afford all the data required.

Why the process of extracting rubber should be called 'bleeding' is not clear, especially when the product of such 'bleeding' is directly afterwards called 'milk.' I prefer to use the words rubber-fluids in place of either milk, latex, or blood The chief merit of this paper, as laid before the Conference, is that it is a record of actual work carried out in Trinidad, and I can only hope that the experience gained will be useful to other Colonies. I am of opinion that there is a good prospect of success for those entering the field as cultivators of the various rubber-producing plants, but at the same time, the matter is one requiring the exercise of the greatest discretion and judgement, as in all similar cases where the cultivator has to compete with forest produce. In the forest, little account is taken as to whether the trees survive the process of extraction or not, and consequently they are treated with greater freedom and large yields are obtained. Such yields could not be expected where the trees are intended to give annual, semi-annual or more frequent returns, as they could not with safety be wounded sufficiently to produce them. What is required by the cultivator, is a regular and permanent paying supply. The exact quantity, which can be taken from trees of a given age, is not as yet known with certainty, as the figures I have mentioned may, on further experience, prove to be either too high or too low. Knowledge of this kind can only come as the result of experience. Some cultivators will be certain to meet with loss, but the man of energy, resource and discretion, will, I feel sure, have a good future before him if he undertakes the cultivation of rubber in suitable localities in the West Indies.

APPENDIX.

Captain Short to the Ceylon "Tropical Agriculturist."

The cultivation of rubber, particularly *Castilloa elastica*, is likely to prove successful in this island. I recently sent to

London a sample, weighing twenty-one pounds, of rubber obtained from *Castilloa* trees I planted on this estate eight or nine years ago. It was valued at 3s. 6d. a pound by Messrs. Lewis and Peat, who report that this rubber would have a ready sale at the price. I cannot yet say what the yield of rubber per tree is here, as the experiments I made in tapping were carried out just after an exceptionally dry season, and being anxious not to run the risk of spoiling the seed-crop, I tapped the trees very lightly. But from a tree tapped lightly on three different occasions at a week's interval, I obtained half a pound of rubber. The *Castilloa* does remarkably well here. One tree eight years old measures five feet in girth at three feet from the ground and another of the same age measures four feet ten inches.

The Louis D'or rubber plantation, started here two years ago, is progressing exceedingly well under the able management of Mr. T. Orde. The estate has now 160 acres of *Castilloa* and forty acres of *Cedra* rubber. There are several other estates in the island now being planted up with cacao, rubber, nutmegs, and coffee, all of which thrive well in the windward and northern districts.

I find that cacao bears very well under the shade of *Castilloa*. Nine years ago I planted an acre of rubber and cacao together—the rubbers at twenty-four feet apart, and the cacao twelve feet--and so far as I have noticed there is very little, if any, difference in the bearing of these cacao trees and those under the shade of the *Bois Immortelle*. On finding this, I planted last year fifteen acres in the same manner, and there is every reason to expect that in another eight or nine years, they will give a gross return of about £50 per acre. Coffee also bears well under *Castilloa*.

A question of great importance to rubber planters is whether a paying quantity of rubber can be got from either one-year old seedlings, or saplings three to four years old. If it proves that this can be obtained, then close planting could be carried out, followed by a quick return. Can you give me any information on this point? Last year I sent to England the bark of a four-year old *Castilloa* tree to be experimented upon. The dry bark weighed two pounds fifteen ounces, and it gave four and a half ounces of rubber, but as this was the result of a laboratory experiment, I cannot say if the process, applied on a large scale, will make close planting profitable or not. Another matter of great importance is to ascertain the quickest and most effective method of tapping the trees.

(Sd.) M. SHORT.

Tobago,

August 28, 1900.

DISCUSSION.

DR. NICHOLLS (Dominica): Mr. Hart has told us that it has been supposed, hitherto, that rubber trees could only grow in very moist soil and in countries where there is a heavy rainfall. I may mention, that about twenty-five years ago, a few rubber trees, *Hevea*, *Castilloa*, and others were distributed from the Royal Gardens, Kew to Trinidad, Dominica and Jamaica. The Dominica tree of *Hevea* has attained much the same proportions as those in Trinidad, being about fifty feet high and of considerable girth. Although rubber has not been extracted, yet, when the tree is pierced, the latex runs out very freely. The tree is growing on the St. Aroment estate, where the average rainfall is over 100 inches a year. *Castilloa elastica* appears to produce good rubber and to do remarkably well in districts in Dominica where the average rainfall is about seventy inches a year. I am satisfied that the soil and climate of that island are suitable for the cultivation of rubber trees.

MR. FAWCETT (Jamaica): In the Jamaica Botanic Gardens we have paid considerable attention to this subject and, although I should be glad to add another industry to our already long list, I cannot advise our planters to go to the expense of planting out rubber on the scale adopted in Trinidad. We find the Central American rubber tree most useful in Jamaica and I am recommending estate owners in some districts to plant these trees along their boundaries so that if they are not used for anything else they will make excellent fence posts. I am also advising them to plant it in their woods so that the seeds may be distributed by birds.

Mr. MILLEN (Tobago): In Tobago rubber trees are grown on the cacao estates for shade purposes. On one estate the growth made by the trees was remarkable. The Central American rubber tree is the one chiefly cultivated. The method at present adopted, in Trinidad and Tobago, of extracting the milk and preparing the rubber is a very expensive one as it takes a long time for the latex to trickle from the trees. The West African method, of making spiral gashes all down the stem, would, I think, be much more economical and would encourage planters to take up the cultivation on a much more extensive scale.

THE PRESIDENT: We have had a most useful paper from Mr. Hart on the prospects of a rubber industry in Trinidad and Tobago. It would appear that started either separately, or associated with cacao, rubber plantations offer a fair hope of success. Whether other parts of the West Indies offer equally favourable openings it is impossible to say. In addition to the facts laid before us by Mr. Hart he has exhibited a valuable series of specimens of rubber prepared from the actual plants under his care. There is one point that is of great interest and deserves attention. That is, the statement made by Mr. Hart that in young plants of *Castilloa elastica* at Trinidad from two to three years old the milk contains little or no

rubber. What was obtained by him was a putty-like mass with little or no elasticity and practically useless. If this applies to young plants of this species in every part of the world it is evident that we must wait several years possibly six to seven before we can hope to obtain an appreciable return from Central American rubber trees. In 1883 I published an account of the *Castilloa* rubber tree of British Honduras and the manner of extracting and curing the rubber.* At that time I recommended that these trees might be used as shade trees for cacao. A trial was made, sixteen years ago, on a cacao plantation on the Settee river and I learn from a letter from the Superintendent of the Botanic Station at Belize dated November 8, last, that the rubber trees have answered admirably for this purpose. He writes "At Kendal on the Settee river the cacao plantations are thriving well . . . *Castilloa* is planted for shade; these were, also, in good condition . . . there is not a better tree for that purpose." I am glad to find that similar results are reported from Trinidad and Tobago. It is evidently advantageous to combine the two cultivations so that in any case no serious loss will fall on the planter. It is well known that the Pará rubber trees are the most valuable of any, but, so far, we have no results from large areas planted with these trees. It has been proved that swampy ground is not necessary but that trees will do well in rich, deep soils in hot districts beyond the reach of floods. I have little hope of the Ceāra rubber trees (*Manihot Glaziorii*) being successful in regular plantations. The yield is so small that, in Ceylon and elsewhere, it has not covered the cost of tapping and collecting the rubber. The "Silk rubber" of Lagos is produced by a quick growing tree (*Funtumia elastica*), which is a very promising rubber plant in the West Indies. We shall probably hear more of this during the next few years. Seed might be obtained in large quantities from the Botanic Stations in West Africa.

PINE APPLE CULTIVATION IN ANTIGUA.

BY THE HON'BLE FRANCIS WATTS, F.I.C., F.C.S.

Government Analytical and Agricultural Chemist for the Leeward Islands.

A pine apple industry with a small export business has been in existence in Antigua for the past twenty or thirty years, and has not only survived in spite of many disadvantages and little encouragement from without, but has even shown signs of growth and development. We are therefore forced to

* *The Colony of British Honduras: its Resources and Prospects*, by D. Morris, Lond: Edward Stanford, 1883.

the conclusion that we have here a legitimate minor industry, possessing inherent vitality, capable of expansion, and located in a district where soil, climate and economic conditions are suitable. Such an industry is deserving of encouragement at the hands of the Imperial Department of Agriculture.

The pine apples are almost entirely grown in the neighbourhood of English Harbour (formerly the Admiralty dockyard), which is situated in the valley at the junction of the stratified tuffs with the unstratified volcanic rocks. The ground is here broken up by more or less steep hills, on the sides of which are the small pine apple plantations. The soil is far less clayey than the majority of Antigua soils as is seen by the following physical analysis of a typical sample.

	Size of particles in millimetres.	*Percentage of particles (Dinsdale).*
Stones	above 5	3·6
Coarse gravel	5 to 2	7·9
Gravel	2 to 1	9·1
Coarse sand	1 to ·5	1·7
Medium sand	·5 to ·25	5·6
Fine sand	·25 to ·1	7·8
Very fine sand	·1 to ·05	3·1
Silt	·05 to ·01	9·1
Fine Silt	·01 to ·005	10.0
Clay	less than ·005	1·4
Organic Matter and Water		7·1
		100·00

A chemical analysis of the fine earth from the same sample gave the following result :

Substances soluble in strong hydrochloric acid.	*Parts per 100 of dry soil.*	
Silica	·533	per cent.
Oxide of Iron	10·675	
Alumina	5·910	
Manganese	·322	
Lime	2·210	
Magnesia	1·826	
Potash	·196	
Soda	·250	
Phosphoric Acid	·035	
Sulphuric Anhydride	·023	
Chlorine	·001	
Water	5·265	
Loss on ignition	7·786	
Carbon dioxide	·037	
Equal to Carbonate of Lime	·084	
Organic Carbon	1·132	
Equal to humus	1·952	
Total Nitrogen	·120	
Potash, soluble in 1% Citric Acid	·0169	
Phosphoric Acid, soluble in 1% Citric Acid	·0064	

It will be seen that this, like most Antigua soils not situated on or near the limestone formation, is poor in carbonate of lime and phosphates. Its physical character, doubtless, fits it for pine apple cultivation. Pine apples will not thrive in Antigua soils which, although possessing much the same chemical composition, differ in physical composition by containing more clay than the above sample, nor will they do well in the limestone district where the soils, in addition to containing considerable quantities of carbonate of lime and being often very friable, contain a large proportion of silt or clay. It would seem therefore that it is the physical, rather than the chemical, character of the soil which largely determines its fitness for pine apple growing, and that it is essential that there should be good drainage and complete absence of stagnant water around the roots. The whole structure of the plant indicates adaptation to a dry district. Its leaves are narrow, their transpiration is restricted, and they are so placed as to conduct the rain which falls upon them to the base of the plant, at the same time holding considerable quantities in the cup-like hollows formed by the over-lapping leaf-bases. The root system is not extensive and its wants can be supplied by a scanty rainfall carefully conserved by a suitable leaf-system.

Until quite recently the cultivation of the pine has been entirely in the hands of the peasantry, but there are indications that people, possessing greater resources, are being attracted to the industry and some larger plantations are being laid out. Consequently we may look for improvement and advance in almost all branches of the industry. The plots on which pine apples are to be planted are worked up by the peasants in the manner in which they cultivate their lands for other crops. The land is forked but not made into ridges or banks as is the case for many crops. Manuring is seldom resorted to. As it is essential that the drainage should be very good, sloping ground is usually chosen and the pine patches clothe the lower slopes of the hills, frequently running into steep positions. When thus steeply situated, certain soils, containing a perceptible quantity of clay, are capable, owing to the thorough drainage, of bearing pines satisfactorily. These soils would be unsuitable if situated in the bottom of valleys or elsewhere on the level. Should there be any great extension of pine growing there are many other localities in Antigua equally well suited to the industry as the one in which it is already established. The line of junction of the stratified and unstratified volcanic rocks runs across the island in a direction from south-east to north-west, from English Harbour to Five Islands Harbour, and along this well marked line there are many places possessing all the necessary requirements.

Pine apples are propagated by means of suckers obtained from older plants. Little or no care is exercised in their selection, they being taken from any convenient or neighbouring field. If purchased, such suckers usually cost from 1*s*. 6*d*. to 2*s*. per 100. They are set out in rows, which are usually from four to five feet apart, the plants being placed two to four feet apart in the rows, the distance varying according to the fertility of the plots, wider planting being preferable on richer soils.

No very definite rules govern the practice, but no doubt these matters will receive more attention in the future as the work falls into the hands of larger holders and becomes more systematic. After a time, the plants throw out new suckers and the ground becomes more and more covered until at last it becomes difficult to make one's way into the plot without cutting a path. There has been a tendency, on the part of some growers, to advise wider planting as a means of improvement, but it is doubtful if this is to be commended. Wide planting means increased cost of weeding. It must also be recognized that the natural habit of the plant is to grow in dense clumps whereby the bearing shoots are prevented from falling sideways, thus shading one-half of the fruit and causing unequal ripening. Where very fine table fruit is cultivated and individual care can be given to the plants these points are of little importance and wide planting or cultivating in pots may prove remunerative, but when the pine apple is grown as a field crop the points mentioned above have considerable weight. Planting is largely carried on during the moister months, from November to February, but it may be done throughout the year. The time of planting has some bearing on the amount of weeding required. There is considerable variation in the length of time elapsing between planting and the ripening of the first crop. On poor lands it may be seven to eight months, while on rich land the period may extend to eighteen months. At the first crop each plant may be expected to bear a fruit; at the second, owing to the increased number of plants by suckering, the number of fruits per acre should be doubled or trebled, and should annually increase until about the fifth year when they may be expected to reach a maximum. The yield is variable, ranging from 1,000 to 3,000 pines per acre. The first crops usually afford larger and softer pines; the fruit of subsequent years being smaller, sweeter and firmer, hence the produce of a plot which has been for some time in bearing is better fitted for transport than the softer pines of the first crop.

The length of time elapsing before it becomes necessary to replant any given area is very variable, ranging from three to eight or more years. It is determined by the size and quality of the fruit produced, and thus really depends on the fertility of the land. As long as a sufficient number of marketable pines are produced the plot is undisturbed, but when this is not so the plot is dug up, the ground tilled and replanted with pines. Usually an intervening crop of sweet potatos is obtained before replanting the pines, or the land is allowed to remain fallow for a time while the cultivator seeks a new spot.

The bulk of the fruit is ready for gathering in May or June but a few pines are obtainable all the year round. For export purposes the fruit is gathered when fully formed but still quite green. Being mainly a peasant industry the facilities for handling and transplanting the fruit are defective, as the pines are frequently grown in localities far away from regular roads and situated upon steep hill sides. Some of the pines are packed in the villages near English Harbour and are sent round to St. John's in small carts and on the backs of donkeys,

and bought from the peasants by dealers who make up small lots for shipment. In many instances the peasant ships his own pines, making up small lots ranging from two to six barrels. In the course of handling before packing there is great risk of bruising the fruit and, unfortunately, insufficient care is taken, as a rule, to avoid this. The pines are packed firmly together, with no wrapping material of any kind, in flour barrels well ventilated with numerous holes in the sides and heads. A barrel will hold from four and a half to five and a half dozen pines, according to size. Practically all the shipments are made by the Royal Mail steamers to London, at fortnightly intervals. This constitutes one of the most serious drawbacks to the industry, as an interval of a fortnight is far too long for a successful fruit trade, much fruit maturing when there is no means of shipping. Consequently there is a tendency to include both over-ripe and under-ripe fruit in every shipment. Some means of shipping at least once a week is urgently needed. I understand that, during the coming season, attempts are to be made to ship, *via* Canada, by the Pickford and Black Steamship Company which, if successful, will afford some relief. Complaints are frequent that the pines are not carefully handled and stored in transit, and that the mail steamers have no facilities for carrying fruit. On a few occasions, though not recently, I believe the mail steamers have been unable to carry the fruit owing to the excess of other cargo, and this has caused much loss amongst a poor class. It is very desirable that a repetition of this be avoided, and it is reasonable to ask that some guarantee be given that the ships will not shut out a perishable commodity which has this sole mode of arriving at its only market. The following particulars as to cost, per barrel of about five dozen pines, of packing and transport have been supplied to me :

	s.	*d.*
Barrel		7
Delivery at sea-board		6
Drogherage to steamer		6
Freight to London...	5	8
London charges	2	0
Total	8*s.*	10*d.*

The local price of pines for shipment varies somewhat, according to the season, but may be taken at one to two shillings a dozen. The prices obtained in London vary greatly, depending in the main upon two factors, the condition of the pines on arrival and the supply of other English fruit in the market. The best prices for good, sound pines, are usually obtainable in May and June, before English fruit is abundant. Frequently much of the fruit arrives in poor condition, being either over ripe and rotten or else too green for sale. During this year prices have ranged from twelve to twenty-four shillings per barrel in London.

The whole of the Antigua shipments go to supply the London coster trade, practically none getting into the hands of better class fruiterers. This trade should be a remunerative

one and may be improved in several directions, the first requirement being a means of shipping, not less than once a week during the crop season, which would result in better and sounder fruit arriving in the market. The fruit should also be properly graded so that the various barrels contain fruit fairly uniform in size. This is a difficult matter in the case of small shipments, but improvements should be made as larger shipments are undertaken. It is found in practice that small fruit is often quite as remunerative as large, owing to the greater number contained in a barrel, and to the fact that, for this trade, soundness and ripeness are more important than size. Probably the barrel will for a long time remain the most convenient package A considerable impetus might be given to this trade if some method of improving the means of distribution in England could be found, as it seems highly probable that a ready sale for sound fruit of this class would be found in the manufacturing districts of the Midlands and the North of England.

The question of improving the pine industry by producing fine table fruit for sale in the shops opens up quite another field, and offers the prospect of a new industry to Antigua. To establish such a trade will be the work of time in which the Imperial Department of Agriculture may be able to render assistance to the larger growers, from whom alone the initiative must come. During the coming season efforts will be made to select fine table fruit and place it upon the market through such channels as will bring it under the notice of the fruiterer. Inquiries should be made as to the possibility of opening up a trade with France and Northern Europe, as there would be no more difficulty experienced in getting fruit to Cherbourg than to London as the Royal Mail steamers call at that port also.

It is uncertain what is the precise variety of pine apple grown in Antigua. The fruit is conical, bright yellow when fully ripe, weighing from one and a half to five pounds, the eyes are somewhat deep and the flavour is good, sweet, and pleasantly acid. The leaves of the plant vary according to age and situation, but are generally reddish green and well armed with prickles along the margin. From a return, supplied by one of the largest shippers, I find that ninety-five per cent. of the pines shipped vary from one to two pounds in weight. With the assistance of the Imperial Department of Agriculture, experiments on the cultivation and manuring of other varieties of the fruit are being carried out, but, at present, these efforts are not sufficiently advanced for any opinion to be formed as to their final success.

Some of the pests and diseases attacking the pine apple require further attention. One or two scale insects are present but they do not appear to be doing much harm. One form of disease, which appears to be of a fungoid nature, and is probably induced by insect attacks, is somewhat common. It is very desirable that this should be thoroughly investigated and remedies sought for. When attacked by this disease the fruit shows little external indication, but when a ripe fruit, thus affected, is cut across. black patches are found in the pulp

which have been put down to over-ripeness, but there is little doubt, in my mind, that it is a specific disease and that the bad condition in which much of the fruit arrives in London is due to this cause.

In order that the industry may attain its fullest development it is desirable that there should be some means of disposing of the fruit more frequently than once a week and, in this connection, one's thoughts naturally turn to the practicability of canning. If this is to be carried on successfully it must be done on a large scale, when it should prove a remunerative undertaking. I see no reason why some enterprising individual should not enter into contracts for a supply of fruit and set up a canning factory in the pine-growing district. There would be no difficulty in obtaining a supply of suitable sugar at low rates, and contracts for fruit could be readily made. Such a factory would give a great impetus to the cultivation of the fruit and improve the quality and quantity of the fruit shipped.

The following table gives the total value of "Fresh Fruits and Vegetables" exported from Antigua and the amount exported to the United Kingdom. In each case the export consists almost entirely of pine apples:

Year.	Total fruit and vegetables exported, (chiefly pine apples).	Amount exported to the United Kingdom (chiefly pine apples).
	£	£
1891	1,189	1,135
1892	810	521
1893	966	806
1894	542	482
1895	1,129	1,070
1896	1,361	1,246
1897	1,111	1,009
1898	1,291	713
1899	2,054	1,161

The average annual rainfall during the period for which these returns are given was thirty-six inches, the minimum being thirty-two inches in 1895, and the maximum forty-eight inches in 1896.

DISCUSSION.

Mr. SHARP (Jamaica): I have listened with great interest to the paper which has been read by Mr. Watts. The system of pine cultivation adopted in Antigua is quite different from that in Jamaica. We are at present engaged in cultivating the smooth Cayenne variety, a pine which cannot be grown from

a ratoon as seems to be the custom with the Antigua varieties This could never be done with the smooth Cayenne which often weighs from ten to fifteen pounds, and which if grown from a side-shoot of the mother plant would be brought to the ground by its own weight, thus destroying the colour which is absolutely necessary in a "fancy" pine. Hence we are bound in Jamaica always to grow each fruit from a "plant."

With regard to the preparation of the soil and the conditions necessary for successful pine cultivation, I may say that slopes are much better than flat land, affording better facilities for drainage. With regard to planting we make our beds slightly oval and plant four rows of pines down each bed. Experience has shown that the feeders of the pine do not travel very far, and therefore we make the rows three feet apart and plant the pines fifteen inches apart in each row. We also carefully remove beforehand the leaf-sheaths from the base of the sucker so as to allow the roots to grow out at right angles. If this is not attended to and the plant is unable to throw off the sheath, the roots early tend to become tangled and often twist around the plant, which although apparently healthy for some time, will sicken and die when the time for reproduction arrives. There are three kinds of suckers which may be planted the crown or head of the pine, the suckers which grow at the base of the fruit, and those which grow on the mother plant. We find if the crown takes twenty-one months to bear, the suckers from the base will take fifteen months, and those from the mother plant about twelve months. Moreover, in selecting plants a sucker of medium size and good vitality is more likely to produce a well-shaped pine than a large sucker. Another important point is to know when the pines are ready to be reaped. The method adopted in Jamaica is to remove the scale from the eye of the fruit. If the scale comes away fairly readily, without bruising the rind, we know that the fruit is fit to be reaped and will not shrink afterwards. The great object in pine cultivation is to produce a fruit large enough to demand a good price. There is one market for pines used in making preserves, one for ordinary table pines, and another for fancy pines. The value of the latter rests on appearance and not on taste.

The Jamaica pines are now seeding very freely, and I would suggest the possibility of carrying out experiments in cross-fertilisation with a view of producing a perfect pine suitable for the highest class market. If the conditions in Antigua are suited to the production of pines, I think it will pay the island to send some of their people to Jamaica to take lessons in growing the best pines. If they do so, I should be happy to give them all the assistance and information in my power.

THE PRESIDENT: Mr. Watts paper has been useful if only in bringing before the Conference the valuable remarks that have just fallen from Mr. Sharp. The latter appears to have thoroughly studied the subject and has contributed a most interesting account of the pine industry in Jamaica. I am glad to find that he advocates close planting in beds and distin-

guishes clearly the relative value, from the crop point of view, of the various suckers to be used. The careful removal of the leaf bases from the suckers, before they are planted, is a very important operation. The neglect of this has no doubt seriously affected experiments in localities where pine apple cultivation has not hitherto been successfully carried on. The circumstances in Antigua and Jamaica are so entirely different that it is impossible to compare them. The chief defects at Antigua are the proper selection and packing of the fruit. It is customary to pack in barrels and this at once renders it impossible to deliver first class fruit in European and American markets. I strongly recommend that an attempt be made to ship a certain quantity of selected fruit in small cases similar to those in use at St. Michael. I purchased a case of St. Michael pine apples in London in October last and it was sent out to Antigua where it arrived with the fruit in excellent condition. The fruits were exhibited at St. Johns, and I trust they served as a very useful object lesson to the shippers of that city. There must be a considerable amount of vitality in the pine apple industry at Antigua, for, in spite of numerous disadvantages, it has survived for many years. It is confined to one district of the island and is carried on almost entirely by small cultivators. I trust that Mr. Watts' interesting paper will be the means of drawing attention to this industry, and that something of a useful and practical character will be attempted in connection with it during the next season.

THE MARINE RESOURCES OF THE BRITISH WEST INDIES.

BY J. E. DUERDEN, Ph D., A.R.C.S.,

Curator of the Museum of the Institute of Jamaica.

An explanation is necessary for the introduction at an Agricultural Conference of a paper on the resources of the sea. Among all the industries of the West Indies that of agriculture undoubtedly predominates, and there is every indication that it will thus continue, and its development constitute the principal means of raising the islands from their present depressed condition. The establishment of this Imperial Department of Agriculture and the presence of so many Government officials and others associated with agriculture, are indicative of the supreme importance attached to the potentialities of the soil in these western possessions of the British Empire. Still, with the exception of British Guiana and British Honduras, the Colonies here represented are all islands surrounded by tropical seas teeming with fish and other forms of life, and even the two Colonies excepted have extended sea-boards. The evilization of their marine resources already plays some limited

part in the maintenance of the Colonies, but nowhere on any organized scale, nor have any other than private attempts been made towards the encouragement and development of fisheries. While so much attention is being directed towards the improvement of the products of the land, my object in bringing this paper before you is to show that the potentialities of the sea likewise call for consideration, and that their encouragement will, in all likelihood, yield results of proportionate value. Further, should any attempt be made to institute marine investigations, the Imperial Department of Agriculture would seem to be the organization with which it could best be associated, such a combination of agricultural and aqui-cultural effort being already followed in Cape Colony.

Everywhere attention is being directed to the development and utilization of the latent resources of the sea. Scarcely a country of any importance, possessed of a sea-board, but has some department charged with the economic investigation of its submerged territories, and the artificial cultivation of many species of fish, lobsters, oysters, and sponges is in places carried out with the same degree of care as that of land crops. Aquiculture has become a recognized industry, just as much as agriculture. I need not do more than recall the splendid work in almost every department of fisheries accomplished by the U.S. Fishery Commission in combination with the efforts of the individual States, the hatcheries of cod and lobsters in British North America, the general efforts of the Scotch and Irish Fishery Boards, the various county schemes (notably those of Lancashire and Northumberland) in England, the extensive oyster and mussel cultures of the west coast of France, and the more recent results at Cape Colony and Australia. Three or four years ago the fishery industry of Cape Colony was in as primitive a stage as that of the West Indies, small boats and hand-lines being the chief implements used. To-day, as a result of the investigations carried out under the direction of a marine biologist, as a sub-division of the work of the Department of Agriculture, a vast enterprise has been built up, and trawling areas of over a thousand square miles have been discovered, and are rapidly becoming an important source of wealth and food supply to the Colony. Stimulated by the success at the Cape a sum of money has been set aside for the purpose of conducting fishery investigations in the waters around New South Wales, and the experiment so far has been a success. Coming within the West Indian area we find that the island of Porto Rico had scarcely passed under the control of the United States before the Fishery Commission steamer "Fish Hawk" was despatched to investigate the possibilities of its surrounding waters, and the preparation of an elaborate report upon the material collected is now in progress.

FISHERIES IN THE WEST INDIES.

To a limited degree fishing is carried on around all the West Indian islands, and much of the fresh fish is considered by Europeans and Americans to be of excellent quality. The

methods of capture employed are somewhat primitive in character, and in no instance is advantage taken of modern improvements. The quantity of fish caught is rarely more than sufficient to satisfy local demands for the fresh article, while no provision is made to supply from local sources the dried, salted, or pickled fish so much in request. At the outset we are confronted with the anomalous condition that the West Indies are small islands, surrounded by wide seas inhabited by large numbers of edible fish, and yet an enormous import trade in salt fish is carried on. In Jamaica the value of imported fish for the last financial year was £117,110, Barbados £27,700, British Guiana £15,858, and Grenada £12,687. The import statistics of the non British islands of Porto Rico and Cuba reveal corresponding amounts. The salt fish comes mainly from British North America Newfoundland and Nova Scotia—and throughout the West Indies constitutes a very important article of food of the peasant classes. In view of this demand the problem which naturally presents itself is whether some effort should be not made to utilize, to a greater degree than at present, the natural resources of the islands.

I have briefly summarized below, from Colonial Reports and other sources, the present condition of the fisheries of the various islands of the British West Indies, and later, some account of the manner in which the industries are conducted, with suggestions for their improvement. In a few instances only are the marine products of any export value to the Colonies, and, therefore, for the most part, no statistics are available as to their quantity and worth.

JAMAICA.

The island of Jamaica has an area of 4,207 square miles, and a coast line of about 400 miles, accessible, at nearly all points, for fishing purposes. The industry is carried on at most of the towns and villages round the coast, but the amount of fresh fish obtained is insufficient to supply the demand of a population of about 700,000, while little attention is given to the preservation of any surplus fish. Fishing is mainly carried on by means of wicker-work pots, seine nets, long lines, and hand lines, but in no case on an extensive scale. Except in seine net operations, there is little or no combination among the fishermen, and apparently the present methods do not admit of much improvement in this respect. Experiments were undertaken, three years ago, to determine the suitability of the waters around Jamaica for trawling and long-line fishing, as these methods are followed in British seas. The results, however, were not encouraging, and are discussed later. The fish obtained around Jamaica is of good quality, the most usual and common being various species of snappers (*Mesoprion*),[1] yellow-tail (*Ocyurus chrysurus*), grunts (*Hæmulon*), drummers (*Larimus*, *Micropogon*) silks (*Tropidinius dentatus*), King fish, and June fish. River and marine fishing for mullets (*Mugil*), calipevers, and snook (*Centropomus*), are pursued to a limited extent. The average price of fresh fish in Kingston is high, being usually sixpence per pound.

An enormous import trade is conducted in dried and preserved fish. In a paper on Jamaica Fisheries, in the *Jamaica Handbook* for 1881, the yearly value of the fish caught is estimated at only £30,000, while the value of the imports of cured fish was then nearly £200,000. This year the value of cured fish imported was £147,110, distributed as follows: Alewives (pickled), £9,378; herrings (smoked), £887; miscellaneous (pickled), £16; salmon (smoked), £16; dried or salted fish, £111,917; herrings (pickled), £17,750; mackerels (pickled), £1,767; salmon (pickled), £2,319. The value of the imported fish is thus four to five times greater than that of the fish caught locally.

Jamaica is also the centre of the West Indian turtle trade, which embraces both the green turtle, used as food, and the shell of the hawksbill, employed for purposes of ornamentation. The green turtle is obtained mainly by the fishermen of the Cayman Islands from around the Mosquito Coast of Central America, and is brought to Kingston, where it is kept alive in "crawls," and shipped to England as required. The value of the green turtle exported last year was £7,218, and that of the tortoise-shell £1,693. In view of the diminution in the supply which is now being felt, I suggest later that the artificial hatching and rearing of both the green turtle and the hawksbill should be undertaken under Government supervision.

At a certain season of the year, March to July, or even later, a small trade in the so-called "booby egg," is carried on between Jamaica and the outlying Pedro and Morant Cays. On these isolated islands thousands of eggs are laid by the "sooty tern" or "egg bird" *(Sterna fuliginosa,* Gmel.) and the "noddy," (*Anous stolidus*, Linn.) These are shipped in boxes of 1,000 each, as many as 200 or 300 boxes being obtained in one season, all of which are retailed in Kingston. The annual value of the eggs is nearly £300.

Other minor marine products used as food in Jamaica are oysters, conchs, lobsters, crabs, cray-fish, and even the octopus.

BARBADOS.

The island of Barbados is justly celebrated for its large flying-fish industry. This, along with the general fishery operations, is mainly in the hands of the poorer classes. Approximately 200 boats are employed, whose crews number about 1,000 persons. The sale of the fish also furnishes employment to a large number, the whole supply being locally consumed. Fish forms a very important staple food of the peasantry during a large part of the year. Two very small whale-fishing ventures are also carried on, the joint exportation of which in 1899 amounted to 254 barrels of oil. An interesting account of the Fisheries of Barbados was prepared by Captain F. R. Barton, and presented as evidence before the West India Royal Commission of 1897. For purposes of ready reference the report is reprinted as Appendix A. to the present paper. Captain Barton therein describes the Barbados Fisheries under three divisions: –

1 "Driving," the method in vogue of taking flying-fish

(*Exocoetus Roberti*), including the capture at the same time of various large fish, the most numerous of which is the [so-called] dolphin (*Coryphaena dorado*).

2. Line fishing. (a) Snappering (*Mesoprion chrysurus*).
(b) Brimming (*Centropristes oculatus*).

3 "Sea-egging." (*Echinus*, etc.).

Under the last heading are included the fish taken by seine nets and in fish pots. The quantity thus obtained is inconsiderable. The flying-fish industry is estimated to yield annually £13,000, the line fishing £2,500, and sea egging £1,000, a total of £19,500. Within the last few years the sea-egg industry in Barbados has become decadent owing to excessive collecting, and, at the request of the House of Assembly, I have prepared a special report on the subject. This is reprinted in Appendix C.

BAHAMAS.

The gathering of sponges in the shallow waters surrounding the Bahama Islands, their preparation for the market, and finally their export to foreign countries is by far the greatest industry of which the Colony can boast. In 1898 the export of sponge to the United Kingdom and the United States amounted to 981,135 pounds weight, valued at £97,512. The industry is described more fully later. Fishing is also carried on to supply the local requirements for fresh fish.

LEEWARD ISLANDS.

Fishing is largely carried on around all the Leeward Islands but, as elsewhere, not on any organized scale. The Colonial Report on the condition of the Virgin Islands during 1897 states that the fisheries there suffer, like fruit growing, from want of cheap and rapid transit. Santa Cruz and many of the other islands have a large demand for locally cured and also fresh fish. No doubt a similar requirement exists in many places too distant for the small sloops used here to reach, and a large market would be opened to the fishermen if some form of steam communication were at their disposal. Grenada has an export trade of turtle shell over £400, and St. Lucia of over £100.

TRINIDAD AND TOBAGO.

Fishing is carried on around Trinidad and Tobago much as in Jamaica. Oysters are plentiful, and are said to be good eating. The manatee or "sea-cow" is occasionally caught. A large quantity of whale oil is sent to the London markets, where it is used for various commercial purposes. It is worth from £14 to £18 per ton.

ST. VINCENT.

Small fishery operations, as well as those involved in the preparation of whale oil and shark oil, are followed around St. Vincent.

BRITISH GUIANA.

The Colonial Reports of British Guiana state that an abundance of fish occurs in the waters of the Colony, but, as an industrial pursuit, fishing is comparatively neglected. Deep-sea fishing has been established, and the market is well supplied with grouper, dolphin, red snapper, etc.

BRITISH HONDURAS.

The fishery industry along the sea-border of British Honduras is only of sufficient importance to supply what is required for the daily and local market.

PRINCIPAL MARINE RESOURCES.

I purpose now to give a short description of the different marine potentialities of the West Indies, with suggestions for their possible development.

MAMMALS.

The aquatic mammals which call for any economic consideration in the West Indies are the seals, the Cetacea (including whales, dolphins, and porpoises), and the Sirenia, (represented by the manatee.)

SEALS.

So far as the seals are concerned their interest to-day is mainly historical. A West Indian seal, *Monachus tropicalis*, was living in some abundance at the time of the discovery of the islands by Columbus, probably extending its range from the Bahamas to the coast of Yucatan and Honduras in Central America. Even in 1707 Sir Hans Sloane writes: "The Bahama islands are filled with seals; sometimes fishermen will catch 100 in a night. They try to melt them and bring off their oyl for lamps to the islands." The oil industry, however, seems to have nearly exterminated the West Indian seal, for the animal has been almost unknown since Sloane's time. It is still represented around some of the less frequented islands, for in Gosse's time (1844-46) a specimen was obtained from the Pedro Cays, and in 1886 upwards of forty specimens were captured around a few uninhabited coral islands between Yucatan and Florida, two living examples being secured for the Zoological Park, Washington.

CETACEA.

The whale oil industry is still carried on to a small degree around some of the islands of the Lesser Antilles though in times past it was of much greater importance. Gosse mentions that an old history (1785) of St. Domingo records that as many as five and twenty vessels from the North American States could be seen near Jacmel fishhing for cachelot whales, the whole of the fishermen resorting to Turk's Island to boil

their oil. The Bahama whale fisheries for the sperm whale (*Physeter macrocephalus*), were also celebrated in former days. The odoriferous "ambergris,"at one time used in medicine and now in perfumery, is a concretion formed in the intestine of the sperm whale, and is occasionally found on the coasts of the Bahama islands.

Companies of dolphins are often seen traversing the length of Kingston Harbour, but no attempt is ever made to secure them.

SIRENIA.

Though less numerous than formerly, manatees or "sea-cows" are still occasionally found in the bays, lagoons, and estuaries of some of the West Indian islands, and at various spots on the Atlantic coast of America, from Florida as far south as the great rivers of Brazil. Specimens are now and then met with around the shores of Jamaica, where they browse mainly upon the "turtle grass" (*Thalassia testudinum*, Kon.). During the past ten years eight have been captured in the vicinity of Old Harbour. One secured in Old Harbour Bay, three years ago, was nearly eleven feet long. The flesh of this was sold in the neighbourhood at fourpence a pound, the fortunate fisherman realizing £8. Gosse quotes that a large sea-cow would sell in Kingston in his time for £18 sterling and that in Port Royal the meat sold at ninepence a pound. Being, like most mammals, very slow breeders there does not appear to be any means by which the number of manatees may be increased, so as to become of greater economic importance.

Another representative of the Sirenia, the dugong, occurs in some abundance in certain parts of the Pacific Ocean, and possesses an important economic value.

TURTLE.

To a greater or less degree, turtle are caught around all the islands of the West Indies, though at the present day they are met with, in quantity, only along the less frequented Cays and sea-coasts. During the turtle season the fishermen visit these remote spots, and bring their captures to the larger islands for sale and distribution. Jamaica is the principal centre of the West Indian turtle trade, the exports for last year amounting to about £10,000. The industry is concerned mainly with the two well-known species of turtle: the green turtle (*Chelone midas*) and the hawksbill (*Chelone imbricata*). That connected with the green turtle consists in the capturing, "crawling," and shipping of the live turtle, and also the drying and preservation of certain parts of the dead animal. The operations associated with the hawksbill are mainly the capturing of the turtle and the stripping off and exportation of the shell. The fish-eating loggerhead (*Thalassochelys caretta*) plays an unimportant part, its shell being of small value and its flesh but rarely eaten. The green turtle is occasionally caught in Jamaica, especially along the sandy coasts of the north side, when coming ashore

to lay its eggs. There is evidence, as is also the case in the other West Indian islands, that in times past the numbers were much greater. For the most part the supply is now obtained from around the Cays and mainland of the Mosquito Coast of Central America; small numbers also come from Cuba and the outlying Cays, such as Pedro and Morant. The trade is mostly in the hands of the crews of small schooners from the Cayman islands, between twenty and thirty vessels being employed. During the season these visit the Mosquito Coast, spend a month or more in capturing the turtle, place them in "crawls" at Cayman, and later bring them to Kingston, where they are again "crawled," and finally shipped alive to England as required. By this arrangement the supply is constant the whole year round. Landed in Jamaica, a good-sized green turtle is to-day worth 24*s*. to 30*s*.; a tax, of 2*s*. per head, having to be paid the Mosquito Government. A few hawksbill are generally captured along with the green turtle. The local value of their shell varies greatly, ranging from 10*s*. to 20*s*. a pound.

Notwithstanding the prolific nature of the turtle there is an evident diminution in the supply, and the Kingston merchants are never able to obtain sufficient to meet the demands for export. But the habits of the green turtle and the hawksbill are such as to lead one to expect that their hatching and rearing would readily permit of control. In view of the greater scarcity which in time must result from the ceaseless capture of the adults, before they have had time to lay their eggs, it becomes a question for serious consideration whether measures should not be taken with a view to the rearing of turtle and the placing of their haunts under supervision. The female turtle lays from 200 to 500 eggs during a season, most of which are successfully hatched; but once the young are free they are subject to innumerable enemies, both before they reach the sea and after, so that an extremely small percentage attain maturity. If, however, they were reared under control up to a certain size, and then set free in the surrounding waters, undoubtedly there would, within a short period, be a vast increase in numbers. Once such operations had passed the experimental stage, it would probably be found advisable for the Government to confer certain rights and privileges on the limited areas occupied by the turtle, and lease these for an annual amount, or place a tax upon each animal shipped, as is done by the Central American Governments. Although no very reliable data are available, yet, from certain experiments and observations, there seems reason for supposing that turtles grow rapidly. If artificially tended for a period of two or three months they would be beyond their most critical time of life and could then be set free. From their rate of growth it is expected they would be large enough for market within two or three years. Although a certain amount of promiscuous distribution of the large specimens takes place, they appear on the whole to keep to the vicinity of their birth. An interesting proof of this occurred a few years ago in connection with a large consignment of Mosquito turtle confined within a crawl in Kingston. One night a severe storm destroyed the crawl,

and the turtle, each of which was branded with the distinctive mark of the owner, were liberated and scattered themselves broadcast. In subsequent captures around the mainland of Central America many of these branded turtle were again caught and once more offered for sale in Kingston. The liberated turtle must have travelled across the Caribbean Sea from Jamaica to the Mosquito Coast, the place of their birth, a distance of four or five hundred miles.

The best method of transportation of live turtle is also a subject of great concern in the West Indies, and has long called for thorough scientific enquiry on the spot. The mortality, between capture and landing in England, varies from 25 to 50 per cent, and is a source of great loss and anxiety to all concerned. The largest shipper of turtle in Jamaica and the Superintendent of the Royal Mail Steamship Co. have expressed to me the great boon which would be conferred upon the trade if investigations could be carried out and results obtained whereby the mortality could be reduced. Hitherto the various precautionary methods employed in shipping seem so haphazard in their results that all interested are uncertain as to which plan is most suitable. Evidently to arrive at any satisfactory solution it will be necessary to follow the live animals from their capture to delivery. No doubt the rough treatment to which they are subjected, extending over a good portion of a year, is responsible for some of the loss; but the whole question calls for careful investigation.

FISHING.

The extremely brief notes already given of the present condition of the Fishery industry around the various West Indian islands suffice to indicate that, while some attention is everywhere given by the poorer classes to the possibilities of the sea, fishing, as understood elsewhere, is comparatively neglected and undeveloped. Yet, no one acquainted with the fish life of the Caribbean Sea, can have any doubt as to its great abundance, and its capability of forming the basis of a large industry, if this be encouraged along right lines.

Though the fisheries of the West Indies may never attain anything like the proportions characteristic of temperate regions, with their vast supplies of cod, mackerel, herring, and allied fish, yet there is every indication that a study and better knowledge of the habits and life-history of the fish, the conditions under which they occur, along with experiments as to the best means of capturing and curing them, will result in the extension of the industry, and thus in the supplanting, in some measure, of the imported cured fish by the native product. Experiments have already proved that the introduction of purely northern methods, without reference to the peculiar tropical conditions will not meet with the greatest success. Any improvement must in a large measure, be the result of local knowledge and investigation, As already mentioned, important fishery operations were carried out in Jamaican waters three years ago. The results are very significant, and will need to be taken into account in any future attempt to develop the

fisheries of the West Indies as a whole. A London Syndicate was formed to examine the possibilities of establishing, in the Caribbean Seas, a fishery industry on a large scale. A report has been published already upon the operations, and is here reproduced as Appendix B. Modern means of fish capture were employed, consisting of otter trawl, long lines, and pots. The venture was not a success, and being only a private undertaking, its efforts were suspended too early to afford conclusive evidence of the actual potentialities of the area investigated. The operations have demonstrated only one important fact, namely, the limited use which can be made of the trawl in tropical as compared with temperate seas, owing to the presence of large areas of coral growth on the sea floor, and perhaps, to a deficiency of bottom flat-fish. Wherever coral is plentiful, trawling is found to be impossible, and around Jamaica it is doubtful if any extensive banks exist which are not thus overgrown. A few trawling areas of limited extent were discovered during the local experiments, and investigations might reveal yet more around other islands. There appears, however, in tropical seas, to be a paucity of bottom flat-fish—sole, plaice, turbot, flounder—such as are obtained by trawling in northern seas.* Sole, and several other Pleuronectids, occur in the West Indies, but apparently never in abundance. The intricacies of coral growth are, however, a very favourite resort for numerous other species. All writers on coral reefs have extolled the abundance and beauty of these fish, which are readily secured by lines and pots.

Line-fishing, as far as a depth of 200 fathoms, is very successful, but the length of line employed with advantage can never equal that of temperate seas. Predaceous fishes, such as sharks and barracoutas (*Sphyraena picuda*), are very plentiful in warmer waters, and fish caught on long lines are very apt to be snapped off by these monsters. The use of the seine and other nets along the shores and shallow banks is very profitable. Schools of migratory fish—herring, June fish, jack, sea-mullet—are met with, but of their habits not much is known, nor the best means of capturing them, nor of preserving them when obtained in quantity. The last remark has also a special application to the flying-fish of Barbados.

Throughout the West Indies the fishery industry is mainly in the hands of the natives, and is conducted without much organization, capital, or enterprise, and, if left thus, development appears practically impossible. In most cases the fishermen are content to earn merely enough to maintain existence,

*Mr. Saville Kent finds practically the same conditions in the tropical waters of Queensland. In *The Great Barrier Reef*, p. 314, he remarks:—"Trawling is not a method of taking fish that is likely to prove remunerative in Queensland waters, and more especially among the intricate channel of the Barrier. In addition to the sea bottom being too rough and uneven for the effective working of the trawl there is an insufficiency of that particular class of bottom fish such as soles, turbot, brill, plaice, skate, and gurnards, of marketable size which constitute the main harvest of the trawl-fisher in European waters. Experiments with the trawl were conducted by the author in both Moreton and Cleveland Bays. The results obtained, however, while interesting from a scientific point of view, yielded little or no materials of commercial value."

and hence the calling is followed in a very desultory manner. The prices realized for fresh fish are generally high, and a few days' labour is sufficient to provide the fisherman for the remainder of the week with the few necessaries of tropical life. Any encouragement of the fisheries should, to my mind, aim at the gradual introduction of more combination and capital, such as are available for the industry elsewhere. This would, undoubtedly, do much to introduce superior methods, more regular application, and more perfect utilization of the results.

The method of fishing, much practised in American rivers and lakes, and known as stake-net fishing, has lately been introduced into Jamaica, and promises to be successful. The net is permanently fixed, and consists of a long leader supported by piles, and at one or both ends of the leader is a large trap, open at the mouth. The leader stretches for 500 feet or more across any course usually followed by fish; these then swim along the obstruction until they reach the trap or crib, through the mouth of which they pass. The fish thus caught accumulate in the large pot and can be taken out alive as required. So far. the operations in Jamaica have been experimental, but they have proved so satisfactory that it is proposed to lay down in Kingston Harbour a full system of the nets. A special Order in Privy Council was lately passed affording privileges and protection to the owners (Appendix D). The initial cost of purchase and erecting a system of say half-a-dozen of these nets amounts to £300 or £400, but, once established, the returns are large, for the processes of collecting the fish and keeping the nets in order can be conducted at a comparatively small cost. The method seems specially fitted for the many quiet bays and lagoons of the West Indies traversed by schools of fish, and will probably be found useful for securing the fish among the coral reefs. It admits of proper supervision, which is not the case with the other methods of fishing at present followed. I feel convinced that, once the plan has been demonstrated to be successful throughout, it will be worthy of adoption by many property owners who at present find difficulty in securing remunerative employment for their capital and energy. There is also every reason to expect that a few such systems established at the most favourable spots would soon result in the capture of more fresh fish than is required locally, and would thus lead to the development of fish-curing stations.

OYSTERS.

One of the curiosities associated with the natural history of the West Indies, and of the tropics generally, is the occurrence of "oysters that grow on trees." Wherever the bent, interlacing roots of the mangrove are immersed in water, and not embedded in mud, they become covered to a greater or less extent with a small oyster—*Ostrea parasitica*, Gmelin. The quiet, muddy conditions, nearly always accompanying the growth of mangroves, seem favourable for the production of the diatomaceous and other microscopic food required by the bivalve. From September to May a small industry is carried on

in Jamaica in the collection and sale of the mangrove oysters, but there is no system of cultivation nor are any restrictions placed upon the number collected. These oysters are much appreciated, and find a ready sale.

In many parts of the world the cultivation of oysters is now carried on as thoroughly and as scientifically as many of the branches of agriculture. More than any other marine industry the rearing of oysters is directly under control, for the molluscs can be followed from the egg, through their free-swimming stage, until deposited as "spat," and then to their marketable condition, which they attain in two or three years. In various places along the West coast of France whole villages are to-day supported almost entirely by oyster culture. According to Prof. Herdman, "the population of Arcachon and the neighbourhood is about 30,000, and of these 12,000 are employed constantly in the oyster *parcs*. About 300,000,000 oysters are produced annually around this one town, their value being upwards of 1,000,000 francs." Considering the vast areas occupied by mangroves on the swamps and flats around most of the West India islands, and their practical unproductiveness, a great possibility undoubtedly exists in their utilization for oyster culture. The cultivation of the mangrove oyster has been strongly recommended elsewhere. Referring to those growing upon the red or orange mangrove (*Rhizophora mucronata*), around Queensland, Mr. Saville Kent observes: "In consequence of its adaptation of contour to its supporting fulcra this oyster is apt to develop a very irregular form of growth; if, however, it be moved at an early stage of its existence, and spread out under favourable conditions for culture on the banks, it has been found by systematic oyster-growers to well repay attention. Oysters of larger, edible dimensions and quality are to be gathered among the fallen debris lying around mangrove trees, where, living more or less remote from one another, they have room for their shells to expand. Giving due weight to this fact, the author is of opinion that remunerative banks, productive of oysters of at least sufficient quality for local consumption, might be initiated, with stock derived from the mangroves. . . In the establishment of such experimental banks attention should be given to imitating, as nearly as possible, nature's own pattern, the banks being formed, not on sun-exposed flats, but within that umbrageous shelter of the mangrove trees where the species attains to its fullest development." In Queensland the areas devoted to oyster culture are leased by auction, for terms of fourteen years, to the highest bidder, and yield the Government a considerable revenue. The mangrove oysters around Jamaica flourish best near the estuaries of rivers, where the water is somewhat brackish, and where, in times of flood, it must be quite fresh. When immersed in water permanently salt, the oysters never attain the same dimensions as where the sea-water is occasionally replaced by that from rivers. A small oyster trade is at present carried on in Trinidad. The principles underlying the rearing of the oyster have been worked out in great detail in several countries, and suitable areas should also be set apart in the West Indies for the same purpose. By this means the

quantity, quality, and size of the crop would soon be improved.

In addition to the oyster, many other edible bivalves occur in the West Indies, the cultivation of which may be found worthy of consideration. Among these may be mentioned the mussel (*Mytilus exustus*, Linn.), the scallop (*Pecten zigzag*, Chemn.), various species of ark shells (*Arca*), and *Codakia* (Lucina) *tigerina*. All of these, especially the last mentioned, occur in abundance in the Indian shell mounds distributed all round the island of Jamaica, indicating that they were utilized as an article of diet by the Aborigines. To-day the larger species of conchs (*Strombus*) and *Turbos* are held in much esteem by the poorer classes, the interest in the conchs being much enhanced by the possibility of discovering specimens of the valuable pink pearl of commerce.

LOBSTERS, SHRIMPS, AND CRABS.

Wherever the sea floor is at all rocky, and among the vast areas of coral growth, lobsters occur in some abundance; the most common species being *Palinurus argus*, Latr. Another species, *Palinurus longimanus*, M. Edw. is rather rare, as also the peculiar and delicate *Scyllarus æquinoctialis*. Very often, in collecting on the coral reefs, by the aid of a water glass, lobsters are seen, slowly walking among the intricacies of the coral growth, or with their antennae projecting from deep crevices or from under coral blocks. The lobsters around Jamaica are mainly caught in fish-pots from amongst the coral, and are kept alive in larger pots near the shore, and taken out as required; a good price, sixpence to one shilling each, being obtained. For many years the artificial hatching of lobsters has been carried on successfully in several parts of the world. Large enterprises associated therewith have been built up in Newfoundland and Canada, while millions of lobster larvæ are annually set free from the hatcheries of the United States and those of the Fishery Board of Scotland. During five years 2,340,657,000 lobster fry were liberated from the floating incubators stationed up and down the coast of Newfoundland, and about thirty three millions of lobsters were in addition produced from the main hatchery. These successful cultivations have a special interest in the West Indies, for there is little doubt that similar operations could be conducted here, were it decided to afford scientific encouragement to the fisheries. Coral areas seem particularly suited to the habits of Crustacea.

During the trawling experiments over the clean floors of some of the bays around Jamaica the large shrimp (*Peneus setifer*), was demonstrated to occur in abundance. A small local shrimp trade is carried on, the prices realized varying from one shilling to one shilling and threepence per pound.

Various species of crabs, of the genus *Callinectes*, occur in Kingston Harbour, and elsewhere in shallow water with a smooth sea-floor. Occasionally they can be purchased at the rate of one shilling per dozen. In the Southern States of America the same crabs give rise to an important industry.

SEA-EGGS.

Barbados occupies an almost unique position in having an important industry founded upon the forms of marine life variously known as Echinoids, sea-urchins, or sea-eggs. Its annual value is estimated at nearly £1,000. Sea-eggs belong to the great group of the animal kingdom known as the Echinoderms, so called from the spiny character of the skin. The group also includes star-fish, brittle-stars, and sea-cucumbers. The Echinoids of the present day are characterized by the possession of a usually rigid, somewhat spheroidal shell, formed of small, closely apposed plates. They possess only a limited power of locomotion by means of organs known as tube-feet. The roe, or reproductive organs of the sea-egg, is the part used as food. For some time past there appears to have been a great diminution in the number of sea-eggs collected, and a Special Committee of the House of Assembly of Barbados was appointed to report on the causes of the decay of the industry, and to suggest remedies. Specimens of the Echinoids, and details of the conditions under which they occur, have been submitted to me, and a report has been drawn up and presented to the House of Assembly. The report is reprinted as Appendix C. of the present paper, hence I need not enter into details as to the suggestions recommended, but merely mention that I advise that investigations into the life and habits of the sea-egg should be carried out, with a view to the adoption of measures for the artificial re-stocking of the exhausted waters. The life-history of Echinoids generally gives every reason to suppose that artificial rearing could be carried out, and the larvae liberated at the time they were about to take on the mature form. An experiment of this character would possess the greatest interest to the practical zoologist, and there is every indication that it could be made successful in restoring an almost exhausted industry.

HOLOTHURIANS, BECHE-DE-MER, TREPANG, SEA-SLUGS, OR SEA CUCUMBERS.

These marine forms, under whichever of the above terms they may be known, belong to the same group of the animal kingdom as the sea-eggs or Echinoids, namely, the Echinoderms But instead of having a more or less hard, rigid shell, like the sea-eggs and sea-stars, the skin is tough and muscular, the body is elongated, and capable of extension and contraction. Seen on the sea-floor Holothurians appear as cucumber or sausage shaped slugs, and move about by means of numerous rows of tube-feet on the slightly flattened lower surface. The anterior extremity is provided with plumose or dendriform tentacles, while the vent is at the opposite extremity. When fully-distended specimens are taken from the sea and handled, water is expelled and the body collapses somewhat, the viscera at times undergoing ejection. Sea-cucumbers vary greatly in length. Perhaps the majority are six or eight inches long under their ordinary condition, and two or three inches in diameter; but some attain a length of one or two feet. Different specimens

also vary in colour and surface details. Some are light coloured, others black, others again are brown, while many are strongly spotted or mottled, and usually they are darker on the upper than on the lower surface. The external surface of most appears warty or tubercular. The Jamaican species have not yet been specially identified, but most belong to the genera *Holothuria* and *Stichopus*. Holothurians live on the sea-floor, from shallow to deep water, and thrive mainly upon small animals or whatever organic debris there may be in the sand or mud which they swallow and pass through their long alimentary canal.

The dried skin of the sea-cucumber, known as bêche-de-mer or trepang, forms an important article of commerce in the southern seas, being largely used by the Chinese for making soup. The annual export value to Queensland, Australia, is about £23,000. The method of collecting and curing is thus described by Mr. Saville Kent in *The Great Barrier Reef of Australia*: "The 'fish' are first collected in sacks by wading or diving off the reefs during the low spring tides. They are then, immediately on their arrival at the depôt or curing-station, placed in large iron cauldrons, and boiled for twenty minutes. They are next taken out, split up longitudinally with a long, sharp-pointed knife, gutted, and exposed on the ground in the sun until the greater portion of the moisture has evaporated. The largest specimens, such as prickly or teat-fish, are frequently spread open, so as to dry more readily, with small, transversely-inserted, wooden splints. The greater amount of moisture having been got rid of, the fish are transferred to the smoke-house. The wood most in favour for the smoking process is that of the red mangrove (*Rhizophora mucronata*). Twenty-four hours is the usual period for which bêche-de-mer are left in the smoke-house By the end of that time they have, for the most part, shrunk to a length of six inches or less, and in aspect they may be likened to charred sausages. They are then ready for bagging up and despatch to the nearest market.

"The fishery for bêche-de-mer is carried on chiefly by means of small luggers of five or six tons burden. These make daily voyages from the curing-stations to the neighbouring reefs which are exposed only at low water, or a fleet of them may remain in the vicinity of the reefs, one or more acting as tenders to convey the fish to the curing-station, and bring back supplies." The collection of the living bêche-de-mer is accomplished during low tides in the new and full phases of the moon, and eight or ten days in each lunar month are thus not profitably utilized. The greater portion of the bêche-de-mer is simply picked off the reefs when the water has receded; but the red and black fish, and the prickly fish, almost exclusively, are obtained, by diving, during the same low tides, from a depth of two or three fathoms."

Practically all the Australian bêche-de-mer is sent to China. A small proportion is consumed in Australia. Bêche-de-mer soup, skilfully prepared, is regarded by many connoisseurs as the equal of turtle soup, and, according to Mr. Saville Kent, is already a favourite in the *menus* of the leading clubs and hotels in all the Australian capitals. Probably a score or

more of different species of sea-cucumbers occur in the West Indian seas: numbers of individuals are met with in the harbours and bays, and less so on the reefs. Wherever extensive coral flats are formed, bêche-de-mer is most likely to occur in abundance, but such areas are not characteristic of the waters around Jamaica. When trawling over the clean sandy floor of Old Harbour Bay nearly half the contents of the net consisted of large, light-coloured Holothurians. Experimental shipments of bêche-de-mer were carried out, a few years ago, at the Caicos islands with the object of supplying the Ameri can Chinese with their favourite article of diet.

SPONGES.

The West Indies and Florida, along with the Mediterranean, are the principal sponge-producing areas of the world; but the fine bath sponge occurs also along the shores of Australia and elsewhere. Sponges grow attached to rocks, stones and other objects on the sea-floor, and the methods employed in collecting them depend upon the depth at which they are living. In comparatively shallow water they may be loosened and hooked up by a harpoon; at greater depths, 50 to 100 fathoms, they are dredged with a net. The use of diving apparatus has also been recommended.

The shores around the Bahamas are the best known sponge grounds in the West Indies, but bath sponges also occur, though less abundantly, on the north coast of Cuba. The gathering of sponges in the shallow waters around the Bahamas, and the preparation of them for the markets, and finally their export to foreign countries is the greatest industry of which the Colony can boast. By what is regarded as a wise enactment the use of dredges and diving operations has always been absolutely prohibited, though it is probable that at greater depths the yield would be much richer and the sponges of finer texture. The Bahama sponges are gathered by means of two-pronged forks attached to staves about twenty-five feet in length. In their natural state they are covered with a black gelatinous substance, the flesh of the animal. Formerly this was removed by burying the sponges in the sand for some days, and then beating them with sticks. Now they are kept on the decks of the sponging boats for three or four days, then put into a 'crawl' and afterwards cleaned and spread out on the beach until they are bleached, when they are trimmed and packed for exportation. After being cleaned, they are brought to the Sponge Exchange in Nassau, where they are sold by auction, being divided into various classes according to their relative coarseness, or other peculiarities. During nine months of the year the sponge-fishery provides occupation for large numbers of men and boys, and over 500 small schooners are engaged in it. The processes of clipping, trimming, and packing always give employment to a number of women. The present annual value is nearly £100,000.

Florida, in the United States, is also an important sponge producing area. There are to-day 310 vessels with more than

2,000 men employed in the industry, and it is estimated that the crop this year will have a commercial value of £170,000. Sponges are found on the eastern and western coasts, but are more abundant on the west coast, owing to the equable temperature and moderate depth of water, and the absence of fierce hurricanes. The sponge grounds of the Gulf of Mexico extend from the Florida reefs for a distance of fifteen miles from the shore. The United States Government has undertaken the investigation of the Florida sponge grounds, with a view to a better development of the industry. The Fish Commission steamer "Fish Hawk" is now in Florida, with a full staff of officers and men, to take charge of the work. It is stated that "while the biological aspects of the sponges will not be neglected, the investigations will be addressed primarily to the economic question involved, with a view to a development of the industry. The great extent of the grounds will probably necessitate two seasons' work." Successful experiments in the artificial propagation of sponges by transplanting and by cuttings, have already been carried out in the Mediterranean, and more recently in Florida. Suitable pieces of sponges, carefully cut off larger masses, will remain alive and continue to grow if placed under favourable conditions. The cuttings grow to three or four times their size in one year, and in five to seven years are large enough for the market. An attempt to establish a sponge industry has lately been made in British Honduras, but, for some reason, has not succeeded.

One of the noteworthy features of the recent trawling experiments in Jamaican waters was the large amount of sponge material brought up, some of the masses attaining a diameter of two or three feet. Although few of the species were of any economic value still the richness of the growth was sufficient to demonstrate the suitability of the area for sponge life, and no doubt the fine varieties would grow just as well as the useless kinds.

MARINE BIOLOGICAL LABORATORY.

Not only are the West Indies favourable for the initiation of fishery investigations, purely economic in their purpose, but they offer a suitable field for the prosecution of marine researches of a more restricted scientific character. Year by year Jamaica has been visited for this purpose by parties of American biologists, and the many memoirs already published upon material obtained, demonstrate the richness of the island in animal forms suitable for original researches. Such visits would become more frequent, and their value be greatly enhanced, if some properly equipped laboratory were provided. Various schemes have been proposed in Jamaica for the formation of a permanent Marine Laboratory in which investigations into the life-history of the animals collected could be conducted. In the past the idea has received the public support and encouragement of Lady Blake, the late Prof. Huxley, and Prof. Ray Lankester, while the Institute of Jamaica has at times made recommendations of a like character. Some eight years ago the subject was discussed in the English *Times* and various

scientific journals. In its comment upon the project, *Natural Science* (April, 1892) observes: "The important results which have accrued from the establishments of marine biological stations, like those of Naples and Plymouth, in temperate regions, lead us to hail with pleasure the proposal to found a similar station in the West Indies. The scheme, which is connected with the approaching celebration of the fourth centenary of the discovery of America, has been ably advocated by Lady Blake, wife of the Governor of Jamaica, in a letter to the *Times*, and has already received cordial support from many of the most eminent men of science in this country, among whom Prof. Huxley has emphasized its importance in another communication to the same journal. It is proposed that the new establishment shall be called 'The Columbus Marine Biological Station,' and it is to be hoped that it will receive support not only from this side of the water, but likewise from our Trans-Atlantic cousins. No such station yet exists anywhere within the tropics, and, judging from the accounts which have been given of explorations with the surface net, and by other means, Jamaica seems to be one of the most favourable localities for such an institution that could possibly be chosen. As Prof. Huxley observes, "animal life is indescribably abundant and varied in the intertropical seas; but the mere fringe of it has, as yet, been skimmed by naturalists under difficulties, literally cribbed, cabined, and confined on board ship, and at best unable to do more than collect and observe. Systematic investigation of more difficult problems—for instance, those of development—which are of such vast importance to the modern biologist, has been out of the question." The report of Prof. W. K. Brooks in the *John Hopkins University Circular* for February, 1892, alone suffices to show what success may be expected in Jamaica. With fourteen colleagues he spent last summer at Port Henderson, in Kingston Harbour, opposite Port Royal, and materials were obtained for many important researches. Among other novelties, Prof. Brooks secured a good series of the successive stages in the development of the minute Crustacean *Lucifer*, sufficient for the preparation of an elaborate memoir on the embryology of that interesting organism. Lady Blake estimates the expense of the undertaking at £15,000, and such a sum ought surely to be raised with no great difficulty if the two English-speaking nations on both sides of the Atlantic would make a united effort to raise a monument worthy to commemorate the discoverer of the New World. No definite details are given in Lady Blake's letter as to the precise plan on which the establishment is to be founded, although we presume from the estimate of the cost that these have been carefully thought out. In a third letter on the subject Prof. E. Ray Lankester calls attention to the need of such details, and lays especial stress on the necessity of an adequate scientific and working staff, as well as the importance of having a good cruiser attached to the establishment. With these observations we cordially agree, although we venture to think that those who have had experience of a tropical climate will attach more importance to the need for good, substantial buildings than he is inclined to give. We shall, however,

doubtless soon be furnished with further information from Jamaica on these points as the scheme matures, and in the meantime we wish it every success."

In a scheme lately submitted to the Board of Governors of the Institute of Jamaica, I suggested that a small beginning towards a marine laboratory might be made at Port Royal, under the control of the Institute. Under the present financial depression in the island it does not seem likely that any local pecuniary assistance would be forthcoming, but the status of the Institute, and the scientific work already accomplished by it, seem to warrant it in appealing for funds both to the English and American scientific societies. The plan has been warmly approved of by Prof. G. B. Howes. Unfortunately, the necessity for retrenchment on the part of the Government has fallen so heavily upon the Institute of Jamaica that, for the time being, there seems little prospect of that organization being able to further the project.

The numerous marine laboratories now in operation in nearly all parts of the world carry on both economic and purely scientific researches in combination; indeed, it is usually difficult to make any distinction between the two. The researches of apparently purely zoological interest conducted at the Plymouth Laboratory often become of use to the Board of Trade in the regulation of the British fisheries, while those of a like character carried out by the American biologists at Woods Holl and other centres play an important part in the development of the vast resources of the sea, rivers, and lakes of the States. Once established, the actual working expenses of a marine station are small. The Liverpool Marine Laboratory costs only about £200 per annum, although utilized by a large number of workers, and producing very valuable results each year. One of the principal sources of expenditure of a laboratory in the West Indies would be the providing for a thoroughly trained biologist, to conduct investigations and to take charge of the laboratory generally. Elsewhere, such positions are often honorary, being held by a naturalist with some other permanent post. At a West Indian laboratory could be conducted investigations and experiments into the life-history, habits and best methods of capturing the many species of fish around the coast, as well as the best means of rearing and utilizing the marine forms such as turtles, lobsters, oysters, sea-eggs, and sponges already referred to. It would also become a centre for scientific workers from abroad, desirous of obtaining an experience of the richness of tropical life, or of carrying out researches on forms not obtainable in temperate regions.

RESUMÉ.

In the foregoing I have endeavoured to briefly sketch the present condition of the marine industries of the British West Indies, and to point out some of the directions in which their development may be attempted. But familiarity with the industrial problems of the islands convinces one that the native

population is incapable of initiating the experiments and investigations necessary for this development, and, indeed, such has everywhere been justly regarded as among the functions of Government, and has been freely given on behalf of agriculture. When discussing the economic problems of these Colonies the danger of depending almost wholly upon a single industry is often referred to. The success achieved elsewhere, from the support and encouragement afforded fisheries, leads one to expect that a like result would follow from the fruitful seas of the West Indies: a neglected source of wealth would be opened out which would diminish the expenditure on foreign products, and increase the value of articles at present exported.

The West Indian marine industries should not be allowed to languish, or to pursue their way unaided by scientific investigations and encouragement. Elsewhere this assistance is rendered to a rapidly increasing extent. Reviewing the fishery organizations established in other countries it can truly be said there is scarcely a modern instance of one which has been evolved without some Government assistance, and encouragement at its initial stage. Imperial support for West Indian agriculture has now been given, and the same should be forthcoming for the corresponding marine potentialities, if these are not to be replaced, almost wholly, by imported products. Consider the sponge industry alone. To-day this is an important source of wealth to the Bahamas, the exports for 1898 being valued at £97,512, and the beds show no signs of exhaustion. It is also a flourishing Floridan industry. But the United States Commission of Fish and Fisheries is not content with the status of the sponge in the latter area, and, as already remarked, from the beginning of this year the Fish Commission steamer "Fish Hawk" goes to Florida with a full staff of specialists and officers to carry out investigations with a view to developing the industry. One naturally asks what will become of the sponge industry in the Bahamas, unaided by any scientific encouragement, when placed in competition with that of Florida, assisted by the enormous resources of the United States Fish Commission. The sea-egg industry of Barbados may also be adduced as a more direct argument. Formerly of an annual value of nearly £4,000, it is now in great danger of extinction, apparently from over-exhaustion of the grounds. Yet, were the life-history and habits of the Echinoid known, there is every probability that the areas could be artificially re-stocked at a very small expenditure, and the industry thus saved.

The products of the sea must be treated in like manner to those of the land. We know what improvements in agriculture have resulted from cultivation and the introduction of new varieties, and similar results may be expected from attention to marine products. In the case of cultivations of such marine animals as turtles, oysters, and sponges, which can be kept under control within somewhat limited areas, it seems advisable, after the experimental stages are passed through, that the areas so stocked should be leased by Government to responsible persons, subject to certain regulations and supervision. The

ultimate distribution of creatures like sea-eggs and lobsters will not admit of such restrictions.

Hitherto the West Indian fisheries and the men associated with them have been wholly neglected by the agencies devoted to the improvement and extension of the industrial resources of the islands. Notwithstanding the maritime character of all the Colonies, agriculture, so far, has been the only industry fortunate enough to call for encouragement and to receive it. I believe, however, that the various islands will now be well repaid if they follow the example of practically all other countries with a sea-board, and devise plans for the development of their marine potentialities.

One means, by which enterprise in fishery matters throughout the West Indies could be stimulated, more information brought before the fishermen, and their difficulties and problems understood, would be the holding of conferences at suitable places. The benefits which have already accrued to agriculture by this means, especially in Jamaica, are too well known to require more than mere mention. Conferences of this character are held in connection with the Northumberland (England) sea-fisheries, and appear to be of great value to the men concerned.

Fishery Schools have been established in some parts to afford instruction to the men engaged in the calling. An attendance on Saturday evenings of from twenty to fifty fishermen at lectures with which I was associated in Ireland, is sufficient to demonstrate that fishermen can be given an intelligent interest in their calling, and in the forms of life with which they are brought in contact.

The directions along which development and investigation in fishery matters are most needed at present within the West Indies may be finally summarized:

1. The best methods of capturing and curing tropical fish.

2. Knowledge of the life-histories and habits of the edible and migratory fish.

3. Encouragement of enterprise in fisheries generally

4. The best means of shipping live turtle. Artificial hatching and rearing of the green turtle and the hawksbill.

5. Re-stocking of the exhausted grounds around Barbados with artificially-reared sea-eggs.

6. Oyster, sponge, and lobster culture.

One of the great endeavours of to-day in the West Indies is to supplement, in as many directions as possible, the old industries of sugar and rum by the introduction and encouragement of other products. In the undeveloped resources of the sea the Colonies have a possession which, if rightly used, will constitute a valuable adjunct to the many agricultural efforts.

APPENDIX A.

THE FISHERIES OF BARBADOS.

(REPRINTED FROM THE REPORT OF THE WEST INDIA ROYAL COMMISSION, APPENDIX C., PT. III., BARBADOS, P. 233.)

The fishing industry in Barbados may be summed up under the three following headings:

I. "Driving," *i.e.*, the method in vogue of taking flying fish (*Exocoetus Roberti*), and includes the capture at the same time of various large fish, the most numerous of which is the dolphin (*Coryphoena dorado*).

II. Line Fishing:

(*a*) Snappering (*Mesoprion chrysurus*).

(*b*) Brimming (*Centropristes oculatus*).

III. "Sea-egging" (*Echinus*, etc., etc.)*

It appears that 1,253 males are directly dependent upon fishing for their living. If to this number is added the women who are employed in hawking, etc., a total is reached which corresponds very nearly to the 1,500 persons obtaining a living thereby, as estimated by Mr. Knollys, late Colonial Secretary in the account written by him of the island for the handbook of the Colonial and Indian Exhibition, 1886.

The sailing boats are used for line-fishing as well as for "driving;" the rowing boats are used for line-fishing (if close in shore), "sea-egging," and for landing the flying-fish, etc., from the larger sailing boats. The smaller kind of rowing boat is locally known as a "Moses."

"DRIVING."

The operation known as driving is carried out as follows: The boats get under way before daylight. Each carries a crew of three to four men. At a distance varying from 5 to 12 miles from land the sails and masts are lowered, and the boat is left to drift with the wind and current. A basket is then produced containing a few partially decomposed flying-fish that have been kept over from the previous day's catch. These are pounded up with a stick and the basket is then plunged several times into the sea, and the water allowed to strain through the bottom of the basket. The process is known as "washing" or "scenting the water." Its effect is to attract the flying-fish in the vicinity, which are presently seen swimming up to the boat through the oily track that the preceding operation has produced. Hooks are then baited and upon them some of the flying-fish are easily caught. Hoop nets are now called into requisition, each of some five feet diameter. A fisherman takes a

*Under heading (III.) are included the fish taken by seines and in fish pots. The quantity thus obtained is inconsiderable.

captured flying-fish, and holding it, tail outwards, between finger and thumb behind the large pectoral fins, he inserts the tail and body through one of the centre meshes of the net, the lower segment of which he then with his other hand plunges vertically under water, the body of the fish being meanwhile kept in agitation. The free fish, on seeing their fellow in such predicament, swim quickly towards him, and being sufficiently close, the net, with a sudden turn of the wrist, is canted up, and the fish are ladled into the boat. When numerous, the above method of attracting them towards the net is unnecessary; for they can be simply lifted out in the nets as they slowly swim to and fro. Sometimes, whilst the operation of catching is in full swing, the flying-fish suddenly disappear as if by magic. Instantly the heavy lines are baited with whole flying-fish and thrown overboard, for the fisherman's experience tells him the dolphin are approaching. The first bait out is almost instantly taken up; a short, sharp resistance follows, and the brilliantly-coloured quarry is dragged over the gunwale. There follows a brief period of intense excitement. Probably three or four 6lb. to 12lb. fish are tearing, leaping, and struggling to get free at the same time. The lines get entangled, and the fishermen know that if one of the dolphin gets pricked, the chances are that the whole "set," will take fright and disappear. Dolphin prey upon the flying-fish. They are easily hooked, being extremely voracious, and are welcomed by the fishermen who always find a ready market for them ashore.*.

King-fish and barracouta are taken by towing astern, when sailing, a flying-fish specially prepared upon a hook.

The flying-fish season extends over about seven months—from December to July. After July they become poor in size and quality and develop what are known to the fishermen as "feathers," which are probably some kind of parasite which infests their bodies, and renders them unfit for food.

An average catch may be put down at from 1,000 to 1,500 fish, but it not unfrequently happens that the take reaches as high a figure as 5,000. The heaviest catches are made in April and May. At such times the supply sometimes exceeds the demand, when great quantities are wasted or merely used as manure. The average quantity landed monthly at Bridgetown Fishmarket in a good season is 300,000, and the average price obtained may be put down at the rate of 150 fish for one dollar. The owner of the boat takes a third of the whole catch; the remaining two-thirds is divided among the "hands."

The cost of building and fitting out a flying-fish boat is about $150·00, and the annual outlay in repairs, etc., amounts to about $30·00.

Experiments have been made, from time to time, to preserve the flying-fish; but hitherto, owing to the absence of expert knowledge in the art of preserving fish, or to the effect of the climate upon them before they can be taken in hand, or to the nature of the quality of the fish themselves, such efforts have

* A single boat will sometimes bring in as many as 180 so-called dolphin.

proved unsuccessful Schomburgk, in his *History of Barbados*, published in 1847, refers to similar experiments having been made.

"SNAPPERING" AND "BRIMMING."

"Snappering" and "Brimming" commence as soon as the flying-fish season is over, and continue through the warm months; a few boats however are thus employed throughout the year. The take is seldom large due chiefly to the fact that they are only caught at great depths. The yellow-eyed snapper is found in shallower water than the brim, the length of line used varying from 120 fathoms to 200 fathoms. As soon as the fishermen have taken up their position, by certain points on the land, over some shoal where snappers are known to abound, a killick (usually a large stone) is cast overboard. Each man angles with his own line, the hooks upon which some 15 to 25 in number he baits with small fish previously caught by means of a cast-net in the surf along the shore. When the line has been let down, and the weight at the bottom has touched the ground and been hauled back a couple of feet, the snappers, if there are any below, immediately swallow the baits, and there follows the long, tedious operation of hauling in, hand-over-hand, some 200 fathoms of line. A good day's catch seldom exceeds 25lbs. in weight representing, say, twenty fish. The price realized averages 8 cents per lb. Each man having provided his own gear, gives the owner of the boat a third of his catch, and keeps the remainder of what he has individually been fortunate enough to secure.

"Brimming" (probably so-called by reason of its being carried out on the *brim* of the horizon) is pursued on the same principle as "snappering", but is a still more tedious process, on account of the greater length of line necessary. The depths at which "brims" are usually taken varies from 200 to 300 fathoms, and at a distance of about eight miles from shore. "Brims" runs to a larger size than snappers, not unfrequently scaling as much as 10lb

"SEA-EGGING."

Sea-eggs are protected by law. The close season extends from April to July (both exclusive). During some years a very large number is taken. The ovula, which comprise the part eaten, are said to be very nutritive, and are eagerly purchased by all classes. The average price per shell, which includes the spawn of some ten to twenty sea-eggs, is about three cents. A single shell furnishes a good meal. They are taken upon the reefs surrounding the island, where the boat anchors, and from which the fishermen employed dive with a small net, into which they scrape the sea-eggs with a piece of bent iron. The depth at which they are found varies, but twenty, and even thirty feet is not an unusual depth at which the pursuit is carried on.

Mr. Knollys estimated that the annual value of the fish taken was £17,000; after a careful approximation, however, it

appears that the amount realized falls not far short of £20,000

The following table gives an *approximate* idea of the amounts realized under each heading:

I. "Driving:"	
Flying-fish, dolphin, king-fish, albacore, &c.	£13,000
II Snappering and brimming	2,500
III. "Sea-egging," &c., &c.	4,000
Total	£19,500

APPENDIX B.

JAMAICA FISHERIES

The Operations in Jamaica of the Carribbean Sea Fisheries Development Syndicate, Ltd.

(Reprinted from the *Journal of the Institute of Jamaica*, Vol. II. No. 6, 1899).

The island of Jamaica has an area of 4,207 square miles, and a sea-border of about 400 miles, accessible at nearly all points for fishing purposes. The industry is carried on at most of the villages and towns around the coast, but the amount of fish obtained is far from sufficient to supply the demand of a population of about 700,000. In a paper by Mr. Anthony Musgrave, in the *Jamaica Handbook* for 1881, the yearly value of fish caught is estimated at £30,000, while the value of the imports of cured fish is approximately £200,000. These latter come mostly from Canada and the United States. The amounts appear to be much the same to-day.

Fishing is mainly carried on by means of wicker-work pots, seine nets, long lines, and hand lines, but in no case on an extensive scale. The fish obtained is of good quality, the most useful and common being various species of snappers (*Mesoprion*) and yellow-tail, grunts (*Haemulon*), silks, and the June fish. River fishing for mullets and calipevers (*Mugil*), and snook (*Centropomus*) is pursued to a limited extent.

That the sea was in times past much resorted to for food by the aboriginal Indian inhabitants is proved by the discovery of numbers of fish bones in their shell-mounds, as well as by the abundance of marine shells.

It has long been surmised that the fishery industry is capable of considerable extension, that the waters are teeming with suitable fish, and that with improved modern methods, such as steam-trawling, sufficient fish might be obtained to render the fresh supply more adequate to the needs of the in-

habitants, and that native cured fish might take the place of the imported article.

No attempt at development of any importance had been made until the matter was taken up with great enthusiasm and persistency by Mr. Edward M. Earle. In the belief that he had sufficient data to warrant him in his efforts, for many years he endeavoured to procure the assistance of the Government towards carrying out operations on a very extended scale, to embrace all divisions of the industry. A motion was introduced and passed by the Legislative Council of 1896, authorizing the payment of an annual subsidy of £750 towards the project, the chief condition being that a certain quantity of fresh fish was to be placed on the markets and retailed at a minimum rate.

Though the exertions of Mr. Earle, the Carribbean Sea Fisheries Development Syndicate was formed in England the year following. Its purpose was mainly preliminary and experimental, the intention being to enlarge the scheme if the venture proved successful.

The steam-trawler *Capricornus* was chartered, she having previously been engaged in the Iceland and Faroe islands' fisheries. For the purpose of keeping some of the fish alive until required for sale, she was constructed with a well in the middle, capable of holding about forty tons of water. In such vessels the water in the well is in communication with that of the sea through numbers of holes, and therefore a constant interchange is maintained. The fittings were the otter trawl, long lines, seine and mackerel nets, all in duplicate; and an experienced crew of Grimsby trawlers was selected.

Operations were commenced towards the end of January, 1898, and continued, with more or less interruption, until the middle of March. The result of these is that the representatives of the Syndicate report the conditions as entirely unsatisfactory and as not warranting any further expenditure for continuing the investigations.

It has been considered desirable, however, that the information collected should be placed on permanent record for purposes of future reference in connection with such matters. Even though the experiments have resulted in the present abandonment of the project, so far as Jamaica (the only district investigated) is concerned, yet the knowledge gathered is valuable, both from a commercial and a scientific aspect.

At the request of the Board of Governors of the Institute of Jamaica, Mr. East, the attorney-in-charge of the undertaking, kindly allowed a copy of the ship's log to be made, and has permitted its publication in the present form. The present writer was out on two occasions with the *Capricornus*, and has all along kept in touch with the operations. Thanks are due to Mr. East, Mr. Earle and the skipper for information readily supplied.

METHODS.

A short description of the methods employed is necessary.

Use has been made of the otter trawl, long lines, seine net, mackerel net, and fish pots.

A trawl may be best understood as an enormous sack, one end of which is kept open by some device, while the other remains closely tied. The lower side is dragged over the sea-floor, its free edge scraping up objects such as, star-fish, holothurians, crabs, and flat-fish which lie on or near the sea-bottom, while, through the wide mouth, fish swimming around may also be engulfed. The otter trawl has in a large measure now replaced the older and more familiar beam trawl, and is the form usually employed in British fisheries.

This trawl possesses two large weighted boards placed one at each side of the mouth of the net. To a corner of each board one end of the upper rope of the net is attached, and to the corresponding lower corners the thick rope which drags along the sea-floor. The latter is longer than the upper and lags behind when the trawl is in actual operation. The constant tension on the rope from the vessel, and the resistance of the water on the boards and net, serve to keep the boards in their proper position and the mouth of the net open. The mouth of the trawl employed by the *Capricornus* had an approximate sweep of 100 square feet. Usually pockets project from different parts of the net, the flaps at the entrance allowing the fish to pass in freely from the forward or bunt end of the net, but effectually preventing any return. By the addition of such separate compartments the fish are less likely to be damaged by mingling with the rubbish always accumulating.

When drawn on board, the narrow or cod end of the net is untied, and all the contents drop out on deck. Then comes a time of excitement: the living, active animals, such as the fishes and crabs, gasp and flounder amongst the rubbish, and all hands are employed in selecting the captures of marketable value and transferring them to baskets, or, in other cases, to the water in the well. Everthing edible being secured, the remainder - the rubbish of fishermen—is shovelled back into the sea; and the net is again lowered to scrape up another haul. The time between shooting the trawl and hauling it up differs considerably. At Portland Bight the interval varied from four to five hours, and even then the net was but partially filled. On the Pedro and Morant Banks, however, the trawl was choked with what the fisherman denotes as garbage corals, sponges, etc.—in a very few minutes.

When working the trawl, especially over unfamiliar ground, it is usual to let down a mark buoy, with a small flag attached; or, if at night, with the addition of a lighted candle. To the lower end of the buoy a cord is affixed and connected with an anchor, by which the buoy is rendered stationary. The buoy serves as an indicator of the neighbourhood around which trawling is to be carried on.

In long-line fishing several miles of line are payed out on any one occasion, the operation requiring two or three hours When completed, hauling-in commences from the end first dropped, and proceeds until all is on deck again, the fish caught

being picked off as they arrive. Here also buoys with anchors are attached at intervals along the line, and serve to indicate its position, and, should breakage occur between the buoys, they enable the line still to be recovered. To the primary line short cords are attached terminated by baited hooks, which float a little above the sea-floor. About five hundred hooks are connected with each mile of line. Where predaceous fishes, such as sharks and barracoutas, are numerous, the fish caught on the hooks are likely to have their bodies bitten off, especially when the lines remain down for several hours.

A drift or mackerel net is constructed with meshes of a certain size, and is shot out across a course traversed by the fish. These run their heads through a mesh, but the body is too large to follow. In attempting to withdraw the head, the gill-covers, which point backwards and project slightly, are caught in the net, and thus the escape of the fish is prevented.

The construction and methods of working the seine-net and the fish-pot are so well known in Jamaica as not to require any description.

As shown in the log, printed below, the sounding line often indicated a sandy bottom, where afterwards the trawl would pick up coral. It is evident that the lead would, in most cases, drop through the coral growth and rest on the sea-floor; and even amongst the most luxuriant growth of corals the actual bottom would usually be of coral sand, and this only would stick on the lead and be brought to the surface as an indication of the nature of the floor.

COPY OF LOG OF S.S. CAPRICORNUS.

Thursday, Jan., 27th: At 8 a.m. left Kingston, 10.30, struck the west-end of the California Bank, and sounded to the east-end and back again: found nothing but coral and rocks. At noon lowered the trawl, towed for 10 minutes, then hove up, and found net in pieces, with only one small fish in it. Steamed to the westward of Portland Point bearing N.W., depth 12 fathoms. Let down buoy on the best ground; lowered trawl for five minutes, then hove it up, and found trawl torn in pieces. Steamed to the eastward and lowered trawl again, but it was no sooner on the bottom than it was stuck fast: had to heave it in torn up. All soundings taken showed fine sand. Returned to Kingston.

Tuesday, Feb. 1st: Left Kingston at 5.30 p.m. for Portland Point.

Wednesday, Feb. 2nd: Stopped at 1.30 a.m. and sounded on the Pedro Bank 11 fathoms sand: steered to W.N.W., sounding all time; found white sand and shells, depth 10 to 11 fathoms. 4 a.m. steamed five miles N.W.N., sand and shells. At 7 a.m. dropped marked buoy and lowered trawl, steaming round the buoy. 8.15 a.m. hove up the trawl, found it torn all along the foot, and containing about two tons of broken coral, sponges, lobsters, holothurians and small crabs. At 10 a.m. picked up the buoy and sounded in 11 fathoms, coarse sand and shells. Steamed to N.N.W., repaired trawl, and at 11.45 a.m. lowered

it; at noon hove up trawl, with a few fish in it and torn again. Made for Portland Point, and abreast it at 11.30 p.m.

Thursday, Feb. 3rd: North of Plumb Point Lighthouse, stopped for daylight, then proceeded in Cow Bay to the eastward of Rock Fort, 8.30 a.m. let down trawl, Plumb Point Lighthouse N.W. by north ¾ miles 21 fathoms, muddy bottom; began to trawl, 9.30 a.m. parted quarter rope on trawl, hove up trawl, nothing in it but coral, sponges, etc. Proceeded for Kingston and arrived there at 9 a.m.

Friday, Feb. 4th: Left Kingston 10 a.m. and steamed down into Portland Bight, at 2 p.m. Let down trawl, half a mile off Pigeon Island: 3.30 p.m. hove in trawl, with a large quantity of holothurians, corals, and small crabs. Drifted until 7 p.m. then let down trawl: 9.10 p.m. hove in trawl with about two bushels of fish, and three bushels of large shrimps; 9.45 p.m. let down trawl, again; at 11.40 took up trawl containing two bushels of shrimps and one and a half bushels of fish.

Saturday, Feb. 5th: 1 a.m. let down trawl, 3 a.m. took up trawl with one bushel of fish, and one bushel of shrimps; 3.30 a.m. started for Kingston. 6.30 a.m. let down trawl south of the Portuguese Shoal: 7 a.m. drew up trawl nothing in it. Arrived at Kingston 8.30 a.m.

Monday, Feb. 7th: Made three hauls of the seine-net in Kingston Harbour for bait, not getting any. Took net to the Palisadoes; at 8 p.m. returned with a bushel of bait.

Tuesday, Feb. 8th: Left Kingston at 6 a.m.; 7.30 a.m. steamed S.S.E., three miles from the Portuguese Shoal: at 8.30 a.m. Plumb Point Lighthouse, N.E. by N. Port Royal north, depth 15 fathoms. Let down the mark buoy, and payed out long lines, steaming S.W. by W. ½; 9.15 a.m. finished paying out thirteen lengths (8,320 yards) with fresh bait on 2,080 hooks east end of Salt Pond Hills N. by E. ½ E., Rock Fort Quarry, N.E. by E. Portland Point, W.S.W. Began to haul in lines at noon; much bait gone from hooks, seven sharks on line, and about 60lbs. of fish; much coral brought up on the hooks. Started at 3.30 for Kingston, arrived and anchored at 5.15 p.m.

Wednesday, Feb. 9th: Filled up with freshwater, and at 1.45 p.m. left Kingston: 5.30 p.m. off Portland Point, North one mile; 5.50 p.m. sounded in six fathoms, coral; 6.10 p.m. sounded in eight fathoms, coral bottom; 6.30 p.m. sounded in nine fathoms, sandy bottom; 6.45 a.m. stopped and drifted all night, taking soundings every half hour, finding rocks, coral, and sand in depths of from nine to fourteen fathoms.

Thursday, Feby. 10th: At 6.10 a.m. steamed W. by N.; 6.30 a.m. sounded in fourteen fathoms, coral bottom; 6.50 a.m. sounded in thirteen fathoms, coral bottom; 8.30 a.m. depth thirteen fathoms, fine sand at bottom; 8.40 a.m. fifteen fathoms, sand; 8.51 a.m. fifteen fathoms, sand and shells. Let down mark buoy. Portland E. by S., White Horses, N. by W., Pedro Bluff, W.N.W. Beacon on Alligator Reef, E. by N.: 9.30 a.m. let down trawl; 11.30 a.m., hove up trawl, contained a large quan-

tity of coral, weed, crabs. sponges, and a dozen small soles, many trunk fish, and holothurians; 6.30. p.m. lowered trawl; 7.15 p.m. took up trawl, nothing in but coral and sponges; took up buoy and proceeded for Portland Point.

Friday, Feb. 11th: 1.30 a.m. steamed up to Portland Point stopped and drifted until 6 a.m., then proceeded 7.30 a.m. extreme N.E., and off Portland Point, north three miles, sounded seven and a half fathoms, bottom fine sand, proceeded N. 7.55 a.m. sounded in six fathoms, coral bottom, proceeded; 9 a.m. stopped, centre of Pigeon Island, N. by W. one and a half miles, lowered trawl, and sounded in eleven fathoms, sand at bottom. At noon took up trawl inside Pigeon Island. It contained six shrimps, a quantity of holothurians, and a few small crabs, but no fish. Proceeded for Kingston and arrived there 5.30 p.m.

Monday, Feby. 14th: Left Kingston at 10.15 a.m.; 1.5 Plumb Point Lighthouse abeam. Set course S E. by E.½ E. At 6 p.m. it being dark and not sighting the Cays, hove to for daylight.

Tuesday, Feb. 15th: At daylight proceeded on S E. course and at 8.30 a.m. sighted S.W. Cay. At 10 a.m. anchored off the N.E. Cay in two and a half fathoms, coral bottom; 10.15 a m. took seine-net on shore; 10.30 p m. hauled seine and took two jack-fish; tried the seine again at 6 p.m., with same result, but got half bushel of bait.

Wednesday, Feb. 16th: Six men hauling seine-net on shore, but got nothing; two men on board baiting long lines. 8.10 a.m. men and boat returned to the ship with one large ray-fish and three-quarters of a bushel of bait; 9 a.m. got under weigh and proceeded to S.W.: 10 a.m let down buoy and began paying out long lines baited; payed out three miles of lines, all bait expended. 1.45 p.m. began hauling in lines, found them constantly fouled with coral; 4 p.m. all lines drawn in having taken five sharks of about 10lbs each; about 40lbs. of rock fish, and a long barracouta; 11 p.m. hove to, off Plumb Point Lighthouse for daylight.

Thursday, Feb. 17th: Anchored at Kingston at 8.30 a.m.

Friday, Feb. 18th: 9.30 a.m. left Kingston and when off Plumb Point Lighthouse sounded 110 fathoms, let down buoy, and lowered trawl, but it was no sooner on bottom than it fouled and on heaving in was found very much torn. Returned to Kingston and repaired trawl.

Saturday, Feby. 19th: Hauled seine in Kingston Harbour for bait, but obtained only a few pounds, which were salted. Sent men with seine further down the Harbour for more bait; they returned with two bushels more.

Monday, Feb. 21st: Got some bait this day,

Tuesday, Feby. 22nd: Left Kingston 6.30 a.m. and steamed to the eastward of Plumb Point Lighthouse, and set about three and a half miles of long lines baited, in 110 to 180 fathoms water; 1.45 p.m. began hauling in on the east end of the lines, but line parted and moorings were lost; 2.25 p.m. hauled in on the lines and they again parted. Obtained some dozen of large June and snapper fish, in all 150lbs., and three sharks taken; 4.45 a.m. steamed to the East, North East. Lost 2,880 fathoms

of line with hooks this day. Sounded at 5 p.m. a ship's length from the buoy; no bottom at 160 fathoms, line out; 5.30 p.m. anchored in 150 fathoms, at mud bottom.

Wednesday, Feb. 23rd: Got under weigh at 6 a.m. At 7 a.m. lowered trawl, Lighthouse N.W., Quarry N.N.E., depth 115 fathoms, mud bottom: 7.35 a.m. trawl fouled the bottom, hove in, Lighthouse N.W. by W. Quarry N. by E., Pyramid at Bull Bay N.E. by E. ½ E, Martello Tower N.E. by N., a ship's length from the mark buoy, which is in 115 fathoms. On heaving up, and at the last length the rope fouled on the drum of the wynch. Cleared rope and took two lengths off drum; 9.30 a.m. trawl on board having a small hole in it, trawl being perfectly clean. Made for Kingston and moored at 11.30 a.m. Got seine-net and drift or mackerel nets into steam launch and set later, in the Harbour, in ten of 50 fathoms each.

Thursday, Feb 24th: Hauled in the drift nets at 6 a.m, Contained nothing but four mackerels and many heads of fishes the body having been bitten off by sharks and barracoutas and holes made in the nets by the same fish: 3 p m. took the nets to Port Royal, and set them off the Cays and across the Harbour mouth.

Friday, Feb. 25th: Hauled drift nets and obtained only about thirty pounds of fish: returned to Kingston; 9.30 a m. steam launch with Captain Hool and men went to the Palisadoes; 0.15 returned. Left Kingston 2.10 p.m.; 5.15 p.m. off Pigeon Island in Portland Bight; 6 p.m. let down mark buoy in seven fathoms; 6.15 p.m. lowered the trawl; 10.15 p.m. took up trawl. It contained a bushel of very small fish, about three bushels of shrimps, and eight hundredweight of garbage, such as star-fish, holothurians, and small crabs; 11 p.m. let down trawl again.

Saturday, Feb. 26th: 5 a.m. hove in the trawl. It contained one bushel of very small fish, about two bushels of shrimps, and the remainder all garbage; 6 a.m. took up mark buoy and steamed for Kingston; 9 a.m. anchored.

Monday, Feb. 28th: Went to edge zone of flat of inshore and deep water between the outermost Cays and Plumb Point Lighthouse: dropped ten new bamboo fish-pots ballasted with iron bars and baited: four pots were connected with one buoy, and three pots each to two other buoys: allowed to remain for one day, then brought up with only two parrot-fish and one doctor-fish.

Tuesday, March 1st: Again lowered pots and allowed to remain for two days. Westward current produced by easterly winds washed the pots into shallow water, 15 to 16 fathoms deep, upon the coral flat, and it was found impossible to clear them. Obtained the buoys, but lines had to be broken in two cases; the line attached to the third buoy was almost severed by the coral.

Monday, March. 14th: 2.30 left Kingston for Portland Bight. 6.30 p.m. let down lighted buoy inside Pigeon Island and trawled around; 11.30 p.m. hove up trawl, contained only about one bushel of fish, 12 pounds of shrimps, a few lobsters

and garbage, such as several species of ray, numerous crabs, holothurians, star-fishes, and brittle stars; bottom sandy and weedy, no rocks nor corals; 12 (midnight) let down trawl.

Tuesday, March 15th: 1.30 a.m. hove up trawl with same results as before: 5 a.m. steamed for Kingston Harbour, arrived 8.30 a.m.

Monday, April 11th: 6 a.m. left Kingston for Pedro Bank, a distance of 60 miles. Sounded in 16 fathoms and surveyed bottom for several miles. Lead brought up sand, coral, and shells, weather moderate. 1 p.m. shot trawl and towed for ten minutes. Hauled up, trawl torn to pieces. Brought up seven fish angel-fish, parrot-fish, and coffer fish. Abundance of coral, two massive sponges and numerous small forms; various species of alcyonarians.

Tuesday, April 12th: 8 a.m. arrived in Kingston Harbour.

SUMMARY OF RESULTS.

From the operations and results detailed above, it would seem that the endeavour to establish a trawling industry in Jamaican waters, on the large scale attempted, will not meet with success; firstly, on account of the coral nature of the greater part of the sea-floor rendering the use of a trawl impossible; and secondly, and more important, a general scarcity of bottom fish.

That trawling cannot be carried on over a sea-bottom covered with aborescent corals was clearly demonstrated at the California Bank, Jan. 27; at Pedro Bank, Feb. 2; and around Portland Point, Feb. 9 and 10. On the first occasion the net was torn to pieces in ten minutes, and on the other attempts in even less time. For fishing purposes the Pedro and California Banks are shown to be of practically the same character as the coral flats near Jamaica. The ground trawled at Pedro Bank was evidently one luxuriant miniature forest of corals, alcyonarians, and sponges, with but few fish amongst them. Several tons of such material were brought up with practically no fish. The sponges obtained were remarkable for their variety of form and size, some being massive, almost spherical, and over two feet in diameter. With one or two exceptions none were of any commercial value.

Even where trawling could be carried on over a considerable area, as over the clean sea-floor of Portland Bight, the yield of fish was extremely small. On March 11, eleven hours trawling, in the locality mentioned, brought up only about three bushels of fish and a bushel of shrimps.

The yield in Kingston Harbour is greater, but the fish are usually small. They serve as employment for several parties of native fishermen with seine-nets, but would aid little towards the support of a steam trawler.

Compared with British and many other seas, there is a marked scarcity of bottom flat-fish -Pleuronectidae- including the sole, plaice, turbot, and brill. A dozen small soles were

obtained, on February 10, near Portland Point. No shoals of fish corresponding with those of the herring, mackerel, and cod of other parts were encountered. Such migratory fish as the June-fish and the King fish are known to shoal in our waters, but their movements are not well determined. Only odd specimens were obtained by the *Capricornus*. An enquiry into the habits of such fish should be undertaken.

Long line fishing, where two, three, or more miles of line fitted with several thousand hooks, are put out, will evidently never succeed, as the lines must necessarily remain down for two or three hours. The numerous sharks and barracoutas had, in the majority of cases on February 16 and 22, bitten off the bodies of those fishes which had been caught on the hooks, leaving only the heads. In other cases the lines were fouled by the coral. Short line fishing, as carried out by the local fishermen, where only about 100 yards of line are employed, is moderately successful. The lines are kept down for about an hour.

The seine net, so long employed, in Kingston Harbour and other points of the coast, apparently yields little more than sufficient fish to employ the few men at present engaged. The experiments conducted in the shallows around the Port Royal Cays, at different times of the day on February 15 and 16, gave no indication of better results being obtained there.

As demonstrated on February 23 and 24, the use of the drift or mackerel net, in which the fish are caught by becoming entangled, cannot be recommended on account of the abundance of sharks and barracoutas, which damage both the fish and the nets.

Fish-pots are sufficiently successful in the hands of the local fishermen; but, owing to the coral nature of the sea floor, their use must always be limited.

The experiments indicate that some less pretentious development of Jamaica fisheries should be attempted. A small steamer working more fish-pots than is done at present, an increase of short lines and of trawling and shrimping in such places as Portland Bight and Kingston Harbour might yield sufficient remuneration if carried out on economical lines, and would afford the island the much needed, more adequate supply of fresh fish. It is also very desirable that more attention should be given to the collection of information relative to the shoaling of the fishes.

With the exception of the Pedro, Morant, and California Banks, and the shallows around the Cayman islands, there are no banks at any distance from Jamaica over which fishing can be conducted, unless in vessels constructed with cool chambers. Fish will not keep in the tropics for more than ten or twelve hours, and a distance requiring a time beyond this to land them would necessitate cool chambers. Specimens from deep water, on being brought to the surface, are nearly always so distorted by the expansion of the gases within them as to be rendered useless for market purposes.

SCIENTIFIC RESULTS.

As indicated by the ship's log, an abundance of material other than fish was obtained, and some of this has been generously presented to the Museum of the Institute of Jamaica. It is rarely that in local waters such an opportunity is afforded for collecting marine forms from a depth beyond two or three fathoms. Until the material has been further worked over only the following general results can be given.

Perhaps the most remarkable feature of the hauls from a depth of about ten fathoms was the variety, abundance, and size of the sponges. A dozen or two species of the larger forms, each represented by many specimens, would be procured at one haul. A large, black, massive, almost spherical form occurred in some quantity; specimens five and a half feet round and twenty inches high were dredged. The pores were thickly inhabited by a small species of the Crustacean *Alphæus.*

Hydroids were but sparingly represented. Of the anemones *Adamsia tricolor* (Les.), living on gastropod shells inhabited by the hermit crab *Petrochirus bahamensis*, was occasionally trawled. The Zoanthids *Palythoa* and *Zoanthus*, so abundant in shallow water, were not obtained from depths of about ten fathoms. The bright yellow *Parazoanthus Swiftii* (Duch. and Mich.) was trawled on the Pedro Bank, encrusting a bright red sponge: also an abundance of a probable new species of *Parazoanthus*, almost completely encrusting the stem of a very large Hydroid. It bears a close resemblance to *Parazoanthus dichroicus*, Hadd. and Shack., from Torres Straits. Another small *Parazoanthus* was obtained from Pedro Bank. It occurred in short catenulations embedded in the superficial tissues of a purplish, vase-shaped sponge, but on a second occasion, the polyps were nearly all isolated and, in retraction, appeared as white, circular discs, covering nearly the whole surface of two of the massive sponges.

The corals met with in greatest abundance by the trawl were varieties of *Madrepora muricata.* Sometimes large pieces would be brought up, but usually only the small, more fragile branches remained entangled in the net. A few other species of corals not obtainable from shallow water were also secured.

Next to the sponges the Alcyonarians were the most remarkable, both for number and variety. A few sea-fans, *Rhipidogorgia*, were torn from their attachments; and species of *Eunicea, Plexaura*, and *Xiphigorgia* were often obtained. The hauls on the Pedro Bank contained a large proportion of these forms, suggesting that the sea-floor in some places must resemble a miniature forest.

Amongst the Echinoderms encountered, the Holothurians or sea-cucumbers are of most interest. Where trawling could be carried out over a sandy, muddy, or grassy bottom, such as Portland Bight and in parts of Kingston Harbour, numbers of very large examples were procured. At Old Harbour Bay nearly half the contents of the net consisted of these sluggish creatures. It is from the dried skins of various species of Holothurians that the commercial bêche-de-mer or trepang of

the Southern Pacific seas is prepared on a large scale for the Chinese markets. Its trial in Jamaica may be suggested. Old Harbour and Kingston Harbour yielded a considerable number of the large star-fish, *Pentaceros reticulatus*. At the place first mentioned, a large *Luida*, perhaps *L. clathrata*, Say, was particularly abundant, but out of scores of specimens not one was secured perfect. Many species of Ophiurians occurred wandering amongst the sponges and corals. The sea eggs, *Toxopneustes variegatus* (Lamk.) and *Cidaris tribuloides* (Lamk.,) exist in large numbers in Kingston Harbour and around the Cays.

The common Jamaica lobster, *Palinurus argus*, occurred in most places, especially amongst the corals. They are regularly caught in fish-pots, occasionally in association with *Scyllarus æquinoctialis*. Both can be preserved alive for some time in baskets sunk in the water, or in the well of a boat. The so-called shrimp, *Penæus setiferus* (Linn.), is obtainable in commercial quantities at such places as Portland Bight. About a bushel was secured in eleven hours trawling. Numerous medium-sized crabs, such as *Calappa flammea* (Herbst.), and two or three species of *Callinectes*, were also trawled at this place. Few examples of the different groups of mollusca were brought up by the trawl.

Opportunity was not afforded for the identification of all the fishes obtained, but the following were noted. Small examples of the ground or white shark, *Carcharias terræ novæ*, and of the shovel-nose or hammerhead shark, *Zygæna malleus*, were occasionally found in the trawl and on the hooks. Representatives of the skates and rays included the sea-fiddler, *Rhinobatus undulatus*; the trembler, *Narcine brasiliensis*; and the sting-rays, *Trygon pastinaca* and *Urolopus torpedinus*. Of edible fish were the several species of snappers, *Mesoprion*, *Lutjanus*; the yellow-tail, *Ocyurus chrysurus*; many grunts, *Hæmulon*; sea-perches *Serrani*; the groupers and hinds, *Epinephelus*; and the silk, *Tropedinus*. Of others may be mentioned the many brightly coloured parrot-fishes, *Scarus*, *Sparisoma*, *Pseudoscarus*, obtained mostly from amongst the corals; the drummer, *Conodon*; angel-fish, *Pomacanthus aureus*; doctor-fish, *Acanthurus chirurgus*; sucking-fish, *Echeneis naucrates*: flying-gurnard, *Dactylopterus volitans*; barracoutas *Sphyræna picuda*: herring, *Clupea thrissa*; sea horse *Hippocampus guttulatus*; old-wife, *Balistes vetula*; bessy corea, *Monocanthus vetula*; various species of coffer or trunk fish, *Ostracion*; porpoise-fish, *Tetrodon testudineus*; and sour-sop fish, *Diodon maculatus*.

J. E. DUERDEN.

APPENDIX C.

REPORT ON THE SEA-EGG INDUSTRY OF BARBADOS.

(FROM THE *Barbados Official Gazette*, 1900).

The Clerk of the General Assembly to Dr. J. E. Duerden.

Office,
Public Buildings, Barbados,
February 19, 1900.

DEAR SIR:

Referring you to the correspondence which has recently taken place between yourself and Dr. R. F. Licorish on the subject of the sea egg, I have the honour to forward you a box containing a tin with several varieties of the sea egg. The specimens so largely used for food in Barbados are, however, the three white specimens, and upon these therefore our interest mainly centres. Any light which you can throw on the life-history of this, to us, very important shell-fish, will be thankfully received by the Committee of the House of Assembly appointed to report on the causes of the decay of the Sea-Egg Industry, and to suggest remedies.

I have, etc.,
(Signed) CHAS. P. BOWEN,
Clerk of the General Assembly.

In a communication of May 17, 1900, Mr. W. D. Shepherd, St. Philip Parish, forwarded me the following notes relative to the industry:—

"Probably you are aware that sea-eggs formed a staple food for a few months on the sea-coast in this island. These sea-urchins were very plentiful and large quantities, boat-loads, were daily caught from September to April, the largest find being about October. The quantity considerably diminished from some cause, and the Legislature, with best intentions, provided a close season, from May 1, to September 1, annually. I see now that there was little or no reason in this law. The quantity has continued to diminish, and it would seem as if these articles of food are likely to disappear. The fishermen often swim from the beach to the coral reefs near by, and dive and catch the sea-eggs, and put them into nets with floats, until they have a load to swim back with. Fishermen of experience tell me that places which used to have large numbers of sea-eggs are now quite bare of them, and they have had for some years to look elsewhere for them. The Legislature appointed a Committee to investigate the matter and to suggest a more appropriate time for the close season, if it were found that the present is unsuitable.

"I have taken some trouble to look up this subject, and can find very little definite information on the subject. The knowledge of the life-history of the animal is necessary in order

to determine how best to protect it. The fishermen say that the sea-eggs spawn chiefly in January, and that this should be the close time; they say that small sea-eggs in February become large eatable sea eggs by October.

"The subject is of great importance to us, but legislation without knowledge is useless, if not harmful. The books tell of male and female sea eggs. I do not think that we find any difference in those caught for food. I might mention that probably this food supply would have been wholly exhausted but I am told that in the caves of the rocks the sea eggs are so fastened as to be inaccessible, and these continue the supply."

The collection of sea-eggs received from Mr. C. P. Bowen consists of ten specimens, belonging to two distinct species, readily separated by their size and colour. The larger specimens are *Hipponoë esculenta* (Leske). This is by far the most important species in Barbados from an economic standpoint, and the one concerning which enquiry is specially made. Its edible qualities are emphasized by the specific term *esculenta*, given by its founder Leske, in 1798. The size of the individual and the colour of its spines serve to distinguish the species from all other West Indian Echinoids. The animal attains a diameter of five or six inches, and the shell is usually a delicate purple, the spines short, white, and closely crowded. The smaller species, represented by four specimens, is *Echinometra subangularis* (Leske). Its spines are rather stout, and the colour varies from light to dark reddish brown. It rarely grows beyond three inches in diameter. Both species also occur in numbers around the Jamaican coasts, and are distributed throughout the West Indies, Florida, and the Bermudas. Barbados, however, is the only island in which they attain an economic value as food.

No regular statistics are supplied showing the quantity of sea-eggs collected annually in Barbados, but from the statement that they form a staple food for a few months on the sea coast, and that boat-loads were daily caught from September to April, it is obvious that in the past the supply has been very bountiful. Captain Barton's estimates would give an annual yield of nearly 10,000,000. It now appears that the quantity has greatly diminished, and there is every likelihood that the industry will disappear unless remedial measures are undertaken.

In the absence of any other apparent reason there can be little doubt that the disappearance of the sea-eggs from their former localities is a result of the excessive collecting to which the areas have been subjected. Though free and active for a short period when young, the locomotory powers of adult Echinoids are very limited, so that an area cannot be replenished from the outside, in the same way as with free-swimming fish.

Before any remedial measures can be suggested it is necessary that the life-history and details of the habits of the sea-eggs should be gained. These have not been studied especially for *Hipponoë esculenta*, but the life of Echinoids generally is so very similar that the following facts can be given as applicable to the species under consideration.

LIFE-HISTORY AND HABITS OF SEA-EGGS.

Sea eggs, known also as sea-urchins or Echinoids, belong to the great group of animals known as Echinoderms, so called from the spiny character of the skin. In addition to the sea urchins, the group includes star-fish, brittle-stars Holothurians or sea-cucumbers, feather-stars, and the stalked, deep-water Crinoids. In certain details of their organization especially in the nervous system and sense organs, they are low in the scale of animal life.

The sexes of sea-urchins are distinct, that is, an individual produces when mature either male or female sexual cells. No external differences, however, are presented by which one sex can be recognised from the other. Even the internal genital organs of one sex can scarcely be distinguished from those of the other, expect at maturity, when they sometimes differ in colour, those of the male being usually milky white and the female orange.

The sexual products eggs and semen are ejected freely from the interior of the sea-eggs through apical pores, and fertilization takes place in the sea-water. Sometimes the top of the shell during the breeding season may be seen covered by the reproductive cells. The actual period of ripeness has to be determined for each particular species of urchin, but in temperate seas it occurs mostly in spring and summer. In the case of *Hipponoe esculenta*, ripe eggs have been obtained during June and July. They are shed from the female in large numbers and float in the water. By obtaining the ripe males and females artificial fertilization can be readily carried out by bringing the sexual cells together, and this has been successfully accomplished in the case of *Hipponoe*.

Under suitable conditions the early stages in the development of sea-urchins can be easily followed. The egg does not pass directly into a young urchin, but gives rise to a free-swimming larva, wholly unlike the adult, and known as the Pluteus. The egg is at first spherical and divides into a large number of more or less similar spheres, which ultimately form a hollow ball of cells. At one end of the hollow sphere a depression takes place, followed by an inward growth, and from this and the general internal surface other cells originate. The various tissues of the larva are built up of these cells. The Pluteus larva is totally unlike the adult urchin. It is provided with bands of fine hairs or cilia, by means of which it is able to swim about.

The sea-egg may remain in the free larval stage for several weeks, the exact time not being ascertained, so far as I can find, for any of the West Indian species.

The long free-swimming stage is of great significance, in that it affords the sea-urchins the means of becoming widely distributed and separated from one another. The larvæ are also carried along by currents; further, by means of the tow net, an upward and downward movement has been established depending upon the time of day. In Jamaica waters, the larvæ are found to come to and remain at the surface from midnight

until about sunrise. From sunrise they gradually disappear, and after about three hours they are rarely found at the surface.

The Pluteus larva, as a whole, does not grow directly into the adult sea-urchin; the latter arises, for the most part, from new growths within the larva, and most of the larval structures are absorbed or thrown off.

The young sea-urchin thus originating is globular, and plates of lime, arranged in rows, form a hard rigid shell, which bears movable spines. Through rows of minute apertures in the plates very fine processes of the body can protrude. These are known as "tube-feet," and, on the undisturbed animal, can often be seen as long, delicate, thread-like projections extending beyond the covering of spines. The tube-feet end in a disc, and by means of these the sea egg is able to move slowly; but probably the creatures never travel far from the place at which they originally settle.

I am not aware that investigations have ever been conducted to determine the rate of growth of Echinoids; but I should much doubt the possibility of their attaining maturity within a single year, as has been suggested to Mr. Shepherd by the fishermen. They seem to feed on sea-weeds, and on the organic matter found in mud, sand, and other deposits on the sea-floor.

Many species possess the power of boring into rocks to which they adhere, in which case they appear to become more or less permanently located; others shelter themselves in holes. *Echinometra subangularis* is usually found in holes and crevices. Others partly cover themselves with sea-weed, dead shells, etc. This is a very common habit of *Toxopneustes variegatus*, a small urchin very plentiful around the Jamaican coasts, and occurring elsewhere in the West Indies. *Hipponoë esculenta* also hides itself, though to a less degree.

REMEDIES.

For a determination of remedies to improve the present condition of the sea-egg industry of Barbados, a complete knowledge of the life-history and habits of *Hipponoë esculenta* is desirable, as well as an acquaintance with the local conditions. No literature dealing with the economic aspect of this group of animals is apparently available. The following suggestions can, however, be offered upon the known general facts of the life and habits of Echinoids, but can only be regarded as preliminary with a view to further inquiry.

CLOSE SEASON.

To make a close season of any value it is necessary in the first instance that information should be gained concerning the period at which the eggs are ripened. In temperate regions, possessing seasonal variations, it is found that Echinoderms and other forms of marine life have acquired a very restricted range within which the eggs are shed. In the course of a few weeks the whole process of egg-laying is completed, and is repeated for the same species from year to year. Within tropical

seas, however, where conditions of life are much more uniform throughout the year, it is doubtful if annually recurring periods of sexual activity are so pronounced. My own investigations lead me to think that the intervals of ripeness will be only regular for the individual, not for the entire species; in other words, that different individuals may come to maturity at different times. In this case, eggs may be shed practically throughout the year, and a close season, as such, would be serviceable only for the time during which the particular Echinoids then ripe were permitted to extrude their eggs.

It is worthy of note that the sexual products of *Hipponoe esculenta* have been found to be ripe in Jamaica during June and July, but no attempts have been made to ascertain if individuals in the same state can be found all the year round.

It is very doubtful whether an area once overworked or exhausted can recover in a few years merely by the institution of a close season. Once the number of individuals of a species gets below a certain proportion, the forces tending towards its destruction exceed those in favour of its increase, and it soon becomes extinct in an area unless replenished from outside sources. I have encountered one or two striking instances in Jamaican waters, where, after collecting heavily, the whole of a particular species has in the end disappeared from the locality. The balance of preservative and destructive forces has been disturbed, and the species is unable to keep pace with the latter and slowly disappears.

It is clear from the gradual decrease which has taken place in the quantity of sea-eggs in Barbados that the diminution by collection has exceeded the power of recuperation thrown upon the specimens remaining and the establishment of the close season is proved to be inadequate. I doubt very much whether an exhausted area can recover, except in the course of many years, even by prohibiting operations the whole year round.

PROPAGATING AREAS.

By propagating or nursery areas I signify restricted regions within which no collection of sea-eggs will be permitted at any time of the year, but beyond which the larvae, therein produced, may disperse. As the sea-urchin spends several weeks in its free larval state, there must be during this period ample opportunity for its wide distribution. But it is only during the swimming stage that dispersal can take place, as, once the animal has formed its solid shell, and taken on the adult character, its locomotory powers are extremely limited.

If such nursery districts could have been established and maintained in the early days of the industry there is good reason to suppose that they might have been adequate to replenish the excessive loss from the worked localities. Even yet, if any well-stocked beds remain, the adoption of such a plan would in time be found beneficial. The possibility of such deserves consideration. Probably several closed districts would be required, depending upon the peculiar local conditions, and the distance over which the larvae can be dispersed in numbers.

The selection of the area should also be partly determined by the direction of the prevailing currents, so that the young free-swimming larvae could be carried as desired.

The well-known wide geographical range of *Hipponoë esculenta* should give encouragement to search for new or untried spots.

ARTIFICIAL STOCKING.

Artificial stocking of new and exhausted waters has been carried out so successfully in the case of fish, lobsters, and oysters by the United States Commission and Fishery Boards elsewhere, that the trial of some such scheme in Barbados, for sea-eggs is well worthy of careful consideration. The artificial rearing of the larvæ of Echinoderms is carried on in marine laboratories, to a certain stage, with great facility. Especially is this the case with Echinoids. The larvæ of *Hipponoë esculenta* and other species have been reared in Jamaica, and there is reason to suppose that the process could be conducted with success on a commercial scale. It would probably be found a simple matter to rear the larvæ as far as the period at which they are about to pass into the adult, and then re-stock the exhausted localities with them. The limited power of locomotion possessed by the animals would then restrict their dispersal within the original place of settlement.

Among the details first necessary to establish would be: (1) the time of the year at which the sea-urchins shed their eggs and spermatozoa: (2) the length of time passed in the free-swimming larval condition; (3) the best means of rearing the larvæ as far as their final metamorphosis; (4) the rate of growth of the young echinoids: (5) the best means of re-stocking areas by the artificially reared larvæ. If all these should prove satisfactory it would probably be found economical to permanently maintain such a hatchery.

As already stated, when an area has once become practically exhausted it would take, in all probability, years, and a combination of favourable circumstances, to become re-stocked, if dependent entirely upon natural means. The possibility of the coming together of the sexual products of two widely separated individuals is very remote, and the settling of larvæ from outside areas would take place somewhat slowly. On the other hand, by bringing together ripe individuals and artificially fertilising the eggs, some control over the future distribution of the latter could be exercised.

The early life-history of the sea-urchin, and the habits of the adults are such as to render it a very likely object for artificial propagation, while the past abundance of the animal around Barbados proves that the conditions are eminently suited to its existence, and should be turned to full account.

Once the necessary investigations concerning the development of the species have been made by a biological expert, the subsequent fertilization of the eggs, rearing of the larvæ, and stocking of the waters could be carried out at a very small expenditure by any intelligent person. Apparently the prin-

-cipal necessary requirement would be propagating tanks or isolated areas of the sea, with access to the main body of water under control. If, as seems not unlikely under the uniformity of tropical conditions, the ripening of eggs may proceed all the year round, the stocking could also be continuous, not limited to a restricted period as in similar undertakings in temperate regions.

After considerable experience in rearing the larvæ of different marine animals for purposes of scientific research, I find that such investigations can be carried on in the tropics with as great if not greater facility than in temperate parts. In the establishment of coral growth within aquaria, the tropics has a means of aeration of water not possessed elsewhere. Thus, by the agency of living corals, I have maintained aquaria for several months without ever changing the water or resorting to artificial aeration. This result is due to the combination of living animal and plant which I have found to exist in practically all corals, the physiological activity of the two organisms resulting in their mutual benefit. By making use of such an organic relationship the expense of pumping arrangements could be obviated.

SUMMARY.

From a careful study of the facts in the life-history of sea-urchins generally, combined with an experience of marine life in temperate and tropical regions, I venture to advise your Committee that the establishment of a close season, even if maintained for the whole year round, would of itself for many years probably do little to re-stock the waters of Barbados with their original abundance of sea-eggs. If areas still well stocked could be reserved as nursery grounds then the larvæ from these might in time be able to replenish the exhausted grounds. On the other hand, the readiness with which the eggs of sea-urchins can be artificially fertilised, and the larvæ reared, gives every reason to expect that artificial re-stocking would be successful. Once the life-history of the edible species has been worked out by some specialist, and the best conditions for re-stocking established, the operations could be continued at very little cost.

J. E. DUERDEN.

APPENDIX D.

RULES AND REGULATIONS FOR STAKE NET FISHING IN KINGSTON HARBOUR.

(From the *Jamaica Gazette*, May 10, 1900.)

1. All persons wishing to lay down staked nets, leaders, hearts and cribs for the purpose of trapping fish, must first obtain for each plant, or set of nets applied for, a license from

the Marine Board, and for such license a fee of two pounds (£2) will be charged, and such license shall hold good for twelve months from the date of issue, at the expiration of which such license will expire, but may be renewed on application and payment of a similar fee.

2. No plant, or set of nets, shall be laid down except a license as herein provided has been obtained, and then only at the spot approved of by the Harbour Master, and notice must be given to him before removal of nets already laid down or contemplated change.

3. No person or persons will be allowed to fish with hook or otherwise, or to trespass within a distance of 100 yards from any part of the leader nets. And the holder of any license is required to clearly mark these limits by laying down at each angle of the imaginary line a buoy, the rope or cable from which must not exceed the depth of water where the anchor lies by more than one fathom.

4. Any person or persons committing a breach of these rules shall on conviction before a Resident Magistrate or two Justices of the Peace, be liable to a fine not exceeding five pounds, or in default imprisonment not exceeding thirty days, with or without hard labour.

Approved in Privy Council this eighth day of May, 1900.

T. L. ROXBURGH,
Clerk Privy Council.

THE CULTIVATION OF ONIONS AT ANTIGUA.

BY W. N. SANDS,

Curator of the Botanic Station, Antigua.

The cultivation of onions at Antigua has been carried on for several years. It appears that a Mr. Smith (an old Bermuda grower) was the first person to grow onions successfully in Antigua, which he did for several seasons on a small scale up to 1896, when he grew ten acres at Mackinnons estate. It was however in the season 1895-1896, that onion-growing reached the condition of a minor industry. Towards the end of 1895, owing to the exertions of Mr. Tillson, who was then Curator of the Botanic Station, several acres were planted in different parts of the island. Much interest was taken in the matter then, and, in November 1895, a paper was read by Mr. Tillson at a meeting of the Agricultural and Commercial Society of Antigua on the subject of onion cultivation. The writer pointed out the best methods of culture and made suggestions as to the best means of developing a trade with the United States of America.

The crop which was reaped in February and March 1896, proved very remunerative, especially that grown by Mr. Wilson at Friar's Hill estate. The results proved that Antigua could grow onions in every way equal to those produced in other tropical countries. Samples of the onions grown that season were exhibited by Mr. Wilson and by Mr. Stratton, at a meeting of the Agricultural Society in February, and were admired by the members. At the same meeting Mr. A. Spooner read some notes on onion-growing in Victoria, Australia, as he had had experience of this industry in that Colony.

From 1896 up to the present time several acres of onions have been grown in the island. It was however chiefly through Mr. Smith's first effort and Mr. Tillson's subsequent work that onions are now grown on a commercial scale. I estimate that during the present season seventy acres of onions will be reaped.

The varieties which have been found to give the best returns are the so-called Red and White Bermuda kinds. Others have been tried, such as those producing large crops in Europe and America, but with little success, their tendency being to grow continuously without the formation of a good bulb. Many shoots also are produced from the same plant, each of which produces a number of small worthless onions, instead of the marketable specimen. This fact is no doubt due to unsuitable climatic conditions. The Bermuda onions, on the other hand, are more adapted to the tropics, producing a bulb which often weighs three-quarters of a pound.

The seed of the Bermuda onion was formerly obtained from American nurserymen, but since it has been ascertained that these firms obtain their supplies from Teneriffe, orders are now sent direct by the growers.

A great saving is effected by adopting this course as the price of Bermuda onion seed (white) in America is 10*s.* 5*d.* per pound, while the same seed in Teneriffe is 8*s.* 0*d.* per pound.

Owing to the seed of the onion being small, it is necessary to sow it in well pulverized soil, and accordingly specially prepared nursery-beds are made. The seed is sown in rows, six inches apart. Sowing is commenced in August, and continued every few days, until about the middle of September. Where several acres have to be planted it is an advantage to sow the seed at intervals, as there is a risk of the young seedlings suffering in the seed-beds before they can be planted out, if they are all sown at the same time.

The first system of cultivation in the field was the flat system, such as is practised in other countries, but although a good crop was produced, it entailed extra labour and expense compared with the methods now adopted of growing the onions on land banked for cane, the young canes being planted in the furrows during the time the onions are growing. The cane fields in which onions are grown are heavily manured and banks are thrown up. The soil is of a rich but friable nature.

The banks are thoroughly worked with the hoe, the lumps of soil are broken up and they are then flattened on the top. On the banks as prepared, the young plants brought from

the nursery-bed are transplanted. They should be about four or five inches high, and at this stage would be about eight weeks old. Sometimes four rows of plants are set on each bank, five inches apart, leaving four inches between the plants in the rows. Care is taken to keep the banks clear of all weeds during the time the onions are growing.

In February and March the onions are fit for reaping. The right time being judged as far as possible, by the ripening and drying up of the leaves. With regard to the proper time to harvest the crop more is required to be known. In cooler climates the harvesting takes place when the tops are perfectly dry, and often the tops of the plants are bent over to hasten ripening, but, in Antigua, it has been found that plants with full, ripe looking bulbs, and green tops have better keeping qualities when harvested then than others, of the same crop, whose leaves were perfectly dry. Further experiments are necessary to ascertain more on this particular point. The crop being harvested in the dry season, rain does not interfere as a rule, but the onions are taken, as soon as pulled, to a fully ventilated drying-house, when they are spread out on shelves and on the floor until perfectly dry; when dry they are cleaned, the dry leaves and tops being pulled off. In a good year an acre of land should produce one hundred crates full of onions.

The onions are packed in crates imported in pieces from Canada and put together on the estate. Some are also manufactured locally, barrel staves being used for the sides, and board for the centre and ends, but it is found cheaper to import. The crates are similar to those used for oranges, and, if properly packed, will hold fifty pounds of onions. As in the case of other products, a great deal depends on good packing.

Prices vary considerably during the season, but the first supplies generally realise good figures, as there is then little competition in the market, the Bermuda supplies being a few weeks later than those from Antigua. In Antigua seed is therefore sown as early as possible after the rains start, to secure the New York market. The Intercolonial market is very uncertain; sometimes good prices have been realised, but heavy losses have also been sustained. On the other hand, if the knowledge of the requirements of the other Colonies could be obtained, as was suggested at the last Conference by the President, an intercolonial trade in onions might be carried on with advantage, which growers are confident would be successful if adopted. Last season there was a considerable quantity of onions supplied from Cuba, which reached New York about the same time as the Antigua onions, so that competition is expected in the future from this quarter. As however the cost of production in Antigua is so small, by growing them as a catch-crop, the industry should not be seriously affected. There is, however, the disadvantage that the other onion-producing islands have better steamship facilities than Antigua. The New York steamers calling at Antigua are very irregular and the local agents do not obtain reliable information as to their movements. Crates have often been packed for a certain day named by the agents, but the steamer did not arrive until

several days afterwards, with the result that the onions arrived at the market in an unsaleable condition. Again, in anticipation of the growth of the industry and the possibility of several thousand crates being shipped annually, special storage arrangements should be made and the crates kept apart from sugar or molasses. These are points which require attention, if the industry is to be put on a proper basis.

In conclusion it must be borne in mind that onion cultivation requires careful supervision and attention throughout. Good reliable seed must be obtained, careful handling of young plants and good packing are essential, but if the disadvantages of marketing can be remedied, there is no reason why onion cultivation in Antigua should not be carried on successfully. For much of the information given in this paper I am indebted to Mr. J. Wilson of Belmont estate, a successful grower, who has given me the benefit of his wide experience.

ZEBU CATTLE IN TRINIDAD.

BY C. W. MEADEN,

Manager of the Government Farm, Trinidad,

AND J. H. HART, F.L.S.,

Superintendent, Royal Botanic Gardens, Trinidad.

The introduction of Zebu cattle into Trinidad dates from the year 1879, when three bulls and three cows were imported. Others were introduced about the same time or a little later, by enterprising planters, and the resulting influence on the herds on their estates was markedly apparent. The notes in this paper, however, refer in the main to the work of the Government Farm. The bulls originally introduced were obtained from the East Indian Government Hissar, an establishment maintained by that Government for the production of gun bullocks. This institution does not part with female stock and Trinidad is under an obligation to General Angel of Hissar farm for the purchase of its cows, which were described as pure bred Hurinahs. From this beginning the Trinidad herd has been formed. It has been kept pure, and, by the introduction of a new bull every fourth year, deterioration has been prevented. Photographs and measurements have been exchanged with the Indian Department which show that Trinidad is not only on equal terms with but, in some instances, even in advance of them.

The Zebu or Brahmin is of great antiquity, and the continuity of special characters and form is specially remarkable, naturalists classing it as a distinct species under the name of *Bos indicus*, a name which indicates its native country. The points of a true Zebu are not difficult to describe, but their

crosses are scarcely distinguishable from a pure bred animal, and it is only when an authentic herd-book is available that any positive pronouncement can be made; a state of affairs which obtains in almost any breed of cattle. The distinguishing points of this magnificent breed may be described as follows:—Prominent hump on the forequarter of the male and female– smaller in the latter; long pendulous ears, silky to the touch; heavy dewlap, extending to the lower jaw; short crescent horns; drooping hind quarters; fineness of skin; slender limbs; and tail terminating with a fine trace of black hairs. The appearance of the animal should be calm and dignified, the eye full and prominent, with a look of latent power that can at at times be well displayed. A pure bred bull on his own domain is one of the most stately animals in existence. The Zebu ox is a splendid draft animal, well adapted for tropical agricultural work, extremely active, and possessed of great powers of endurance. His fine limbs, sound hard feet and good action are all in his favour as a working animal. With a minimum amount of feeding and care he is capable of doing more heavy and exhausting work than any other beast of burden in the tropics. Well bred oxen are however somewhat difficult to break in but, once broken, they are very docile and obedient, as can be seen by the way in which little coolie boys are able to control them. The Negro is, as a rule, unable to exercise the same control over this class of cattle as the East Indian driver. Good working oxen are always saleable and the prices realized at the Government sales have invariably been satisfactory, although of late years they have decreased somewhat, owing to the uncertain state of the sugar industry.

As milkers, the pure breed fails in some respects. Most of them resist the restraint which necessarily accompanies the act of milking and in consequence their yield is deficient. Their milk is somewhat weaker than that of ordinary milch cows under the same treatment, the analysis showing as follows:—

	Specific gravity.	Solids (not fat).	Fat.	Ash.	Cream.
Zebu Cow	1031·0	8·0	3·72	·72	4·5
Ordinary Cow	1027·7	9·00	4·55	·75	7·0

The above analysis was made with the afternoon milkings. It would not be fair to the Zebu, however, to condemn them entirely on the trial of their milking qualities in Trinidad. It is certain that for long years in India the milking qualities have not been a first consideration, other points have been considered as of more importance in selection. It is clearly possible that, by proper selection, a strain of Zebu milkers might be obtained little, if at all, inferior to any other class of cattle. This view is strengthened by the fact that individual cows have been found among the herd which have proved themselves excellent milkers. The practice in Trinidad is to allow the calves to run with the dams as soon as they are strong enough, with the object of bringing them forward as fast as possible, and giving them every advantage at the annual sales.

Crossing milch cows with a pure bred bull has often resulted in the production of first class milkers, but the milking qualities appear to suffer if bred too close. A first or second cross produces animals eminently suited to the tropics, inured alike to heat or moisture, invariably thrifty, and giving milk which compares favourably both in quantity and quality with that of any country. What knowledge we have of the crossing of this breed for the production of beef is distinctly favourable, the quality is good, and from the butcher's point of view, they scale well. The waste in offal in animals killed in the tropics is generally greater than in temperate climates, on account of certain local conditions.

Our bullocks from the time they are weaned until reaching four years old are entirely grass fed, except for a short preparation previous to selling. At this age they scale some 1,000 to 1,200 pounds, and are generally sleek and in prime condition for the butcher. Having been fed in clean pastures the meat is tender and entirely free from the large amount of "muscle" which renders the flesh of the imported Venezuelan cattle so tough and tasteless.

Well bred Zebu cattle cannot be termed tractable in the same way as the Hereford, the Polled or the Jersey, but on their own ground they are not difficult to deal with. Trouble arises, however, on their transference from one place to another, or on any alteration in the handling to which they have become accustomed. In such cases they show extreme excitement and are prepared to go over, or through, anything. Another disagreeable feature is their lying down and offering passive resistance when overcome. The best treatment in such a case is, not to beat them or to permit the too common practice of tail twisting, but to fill their nostrils and ears with cold water by throwing it smartly in their faces. Nothing brings them to their feet quicker than this simple and harmless treatment. The plan of dealing with cattle in the Trinidad herd is not to drive them but to call them, rattling the feeding bucket at the same time. Zebus can be easily led, but they cannot be driven. To effect this, one or two of the herd are trained to hand-feeding. They soon recognize the rattling of the bucket, so that when the herd is wanted, the cry of the herdsman and the rattling of the bucket brings them home at a gallop.

Before being sold oxen are put into a reserve pasture which has been shut down in preparation for them, where they remain for some three months, and are hand-fed during this time with a mixture containing cocoa-nut meal, Indian cornmeal, and "middlings" with a small addition of salt and linseed meal, which binds the whole and prevents waste in feeding. The ingredients are made into a mess with water and hand-fed in about half-pound lumps, each animal receiving about three pounds at a time. The mixture is carried to the field in buckets, one man stands guard, while the remainder, taking each a certain number, see that every animal receives its share. This feed costs about five cents a day or 6s. *3d.* per month, and has the effect of putting on a nice clean finish to the animal previous to sale.

For crossing with other breeds there is no better animal than the pure bred Zebu, the cross with native stock giving excellent results. The half or three part Zebu heifers crossed with Devon, Hereford, or Polled bulls, give rise to a very profitable class of stock.

Jamaica has for years been a good customer at the Trinidad sales of pure bred stock, and is probably largely indebted to Trinidad importations for the improvement in her herds. British Guiana, Antigua, Grenada, Honduras, and Venezuela have also been purchasers, and as the export has been in no way restricted, the neighbouring Colonies have been able to take advantage of and to benefit by the Trinidad importations, a privilege of which they have not been slow to avail themselves. It is understood that in Jamaica half-breeds from the Zebu are in great demand and sell at considerable advantage as compared with the native cattle. The value of pure bred two-year-old bulls has ranged from £50 to over £100 in accordance with the size and points of each animal, the number offered, and the number of buyers present. Pure bred heifers are now worth about 75 to 150 dollars, while bulls will probably range from 150 to 300 dollars. As, however, all cattle are sold by auction, this must be taken as only an approximate estimate of the price they are likely to realize.

The Government Stock Farm in Trinidad is now entering on a wider phase of existence, and it is hoped that the management will be able to handle a certain number at least of all the most useful classes of stock. In a short time additions will be made to the Zebu, Guernsey, Red Polled, and Hereford herds, from which it is hoped to secure acclimatized progeny possessing the best characters of the various breeds, and that the support afforded will enable the Trinidad Farm to maintain its position of being one of the best institutions of its kind, and to become the stud farm of the West Indies.

BREEDING FOR BEEF IN TRINIDAD.*

BY C. W. MEADEN,

Manager of the Government Farm, Trinidad.

It is a general belief in Trinidad that our native grasses are not sufficiently nutritious to enable the Colony to produce its own meat supply and particularly of beef. A sum of £40,000 is annually spent in the supply of meat, so that the question is one of sufficient interest to demand thorough consideration. From a purely agricultural aspect the production of beef would form an additional industry, and bring into a

*This subject has already been dealt with by the author in two communications presented to the Agricultural Society of Trinidad which form papers Nos. 98 and 131, in Volume III, pp. 119 and 310 respectively, of the Society's Proceedings. The information contained in the present paper summarizes and carries to a conclusion the history of these experiments. (*Ed.* W.I.B.)

healthy and renumerative condition land which is now waste and a burden to its owners.

In order to bring our natural grasses into good grazing condition systematic treatment is required. Sub-division for the purpose of rest and change, and, where the formation of the land permits, the use of agricultural implements such as the hay-mower, horse-rake, and the harrow, should soon result in the formation of sound feeding pastures.

The present paper deals only with the conditions of Trinidad for the production of beef: that is to say, whether there is suitable land and other facilities, and sufficient inducement in the way of profit to encourage the industry.

That there is land enough is evident from the areas lying idle on abandoned sugar estates, and the great Caroni Savannah,—a menace to health and unproductive. With regard to facilities, there are good roads and railways cutting through what might be the heart of the industry. The market value of the product has already been shown, and a recent rise in the price of meat shows that, at present, there is little danger of over supply. The present meat trade in Trinidad is open to serious interruptions which often renders it difficult to meet the demand, and the poorer people are deprived of meat in consequence. It is therefore very desirable that a reserve supply should be available, that the market should not continue in its present dependent position.

During the last year an experiment in breeding for beef was brought to a satisfactory conclusion, although only carried out in a small way. The subject of the experiment was a cross between a Red Poll sire and an ordinary Creole cow. This steer, when turned out to grass at fourteen months old, weighed 165 lbs. He was kept under conditions such as might be expected would be given in the general way in the Colony, to test the value of grass feeding. The season proved exceedingly severe and grass was scarce. At two years old, he had gained only 83 lbs. As grass became more plentiful a rapid increase in growth ensued, and at the end of his third year, he scaled 770 lbs., showing a gain of 222 lbs. for the latter period. This rate of gain would probably have continued so that at four years old he would, in all likelihood, have scaled 1,100 lbs, the weight of a prime beast in Trinidad. The cost of rearing this animal amounted to $4:80 including milk and feed. The gain in weight during his last year cost two shillings, one shilling land-tax and one for upkeep of fences and land, calculated on the average cost of the herd of oxen running together.

The dead weight was 384 lbs. The animal was in a perfectly healthy condition, every organ sound and, to use a butcher's term, "cleaned well." The meat was tender and juicy and altogether superior to what is generally obtainable, and realized in the open market, sold under the same conditions as any other beef, $32:28, which after paying for slaughtering, market dues and commission left a profit of $27:48 or $9:16 per annum. With a large herd, sufficient working capital, and sound management such returns indicate the possibility of a lucrative industry.

ARTIFICIAL DRYING OF CACAO.

BY G. WHITFIELD SMITH.

Travelling Superintendent, Imperial Department of Agriculture for the West Indies.

The question of drying cacao by means of artificial heat is one which has occupied the attention of planters in Grenada for over a decade. On the mountain lands of the island the annual rainfall often exceeds 150 inches, and, as a large portion of this falls during the months of October, November, and December, when the bulk of the crop is being reaped, it often happens that, on cacao estates situated at high elevations where no provision is made for drying the beans artificially, considerable loss, arising from "mildewed" cacao is the result.

The following is a brief sketch of the efforts which have been made, from time to time, in Grenada to dry cacao by artificial heat. Up to the present, it cannot be said that any of the methods tried have proved thoroughly successful, and a drier in which the hot air from the furnace can be made to circulate freely throughout the entire length of the drying chamber is still the subject of the cacao planter's inquiry.

The first attempt on record to dry cacao by artificial heat is one of about fourteen years' ago when Mr. Frazer, the manager of Annandale estate (then the property of Sir Sandford Freeling) constructed what might more appropriately be termed a cacao "heating" apparatus, on simple and rudimentary lines, for use on that property. In this drier the heat was obtained from a brick furnace not unlike that used in the manufacture of muscovado sugar, except that instead of the tayches there was a flat surface of sheet iron forming the roof and flue of the furnace. About six inches above this was suspended a fine wire-net tray on which the beans to be dried were placed. This constituted the entire apparatus. No attempt was made to shut off the drying surface from contact with the surrounding air and the operation of drying was conducted in a large room open on all sides to the atmosphere. It is needless to say that Mr. Frazer's drier proved unsatisfactory, the beans nearest the fire receiving an undue amount of heat, those farthest away from it none whatever. The next attempt was made a few years later by Mr. Charles Risk, and a working model of the drier made by this gentleman was exhibited at the Agricultural Show held in Grenada in December 1890. Mr. Risk's drier consists, for it is still in use, of a rectangular stone or brick building about twice as long as wide. Running lengthways along the inner sides of this building are tiers of wire-net trays, so arranged as to leave a passage down the centre of the building wide enough to admit of a man passing through the drying chamber from time to time for the purpose of stirring the beans. Except when this operation is being performed the drying chamber is closed to the entrance of the atmosphere by means of close-fitting wooden doors. The heat is supplied from a brick furnace situated outside the building,

and the hot air is conducted by means of a sheet iron pipe (the flue) through the drying chamber, passing under the wire trays already described, and finally escaping through the chimney. As no provision is made for removing the hot and moist air a high temperature (130° F. to 150° F.) is required. Some planters still claim to obtain good results from the use of Mr Risk's drier.

In 1893 the writer (then attorney for the cacao estates belonging to the Hon'ble Messrs. Schooles and Lascelles) erected a drier at Belle Vue estate on the principle of the cacao drying houses used in Ceylon. Dr. Trimen, F.R.S., the late Director of the Royal Botanic Gardens, Ceylon, gives the following description of this drier in the Jamaica Bulletin, No. 41, March, 1893: "The house is about twice as long as broad, built of brick and is provided with double doors, but with the exception of the opening for the ingress and egress of the hot air is hermetically sealed. The interior is fitted with a number of upright frames into which slide, one above the other, the trays upon which the beans are spread; these should be made of narrow pieces of split bamboo, not of wire or coir matting. The heating apparatus is outside in contact with one end of the building, and consists of a large stove standing in a short tunnel which opens into the house. At the other end of the building, also outside, is a powerful fan fitted in another tunnel; this is worked by hand (three or four coolies needed) and by its rapid revolution draws the air through the house. By passing over and round the stove the air is dried and heated; that which passes out is hot and damp. The flue of the stove passes under the floor of the house and contributes to warm it. A drying house of this sort is very simple, and its cost only about £100; it does its work perfectly, and nothing more elaborate or costly is required."

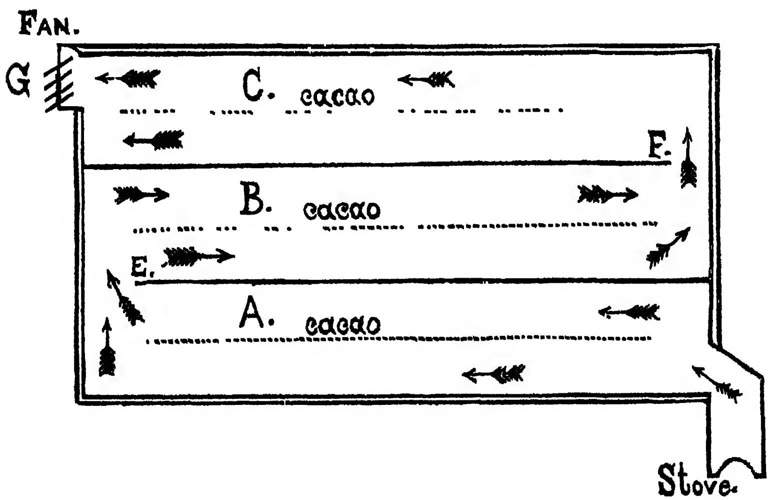
It has been found that by drying slowly, provided the risk of mould be avoided, more satisfactory results are obtained with a low temperature than when very high temperatures are used, and an attempt is made in the drier above described to imitate as closely as possible the conditions under which cacao is dried when exposed to the action of sun and wind. With a few modifications and the substitution of wire trays for those made of split bamboo, this drying machine is the one most in favour with cacao planters at the present time, the only objection to it being that the hot air on entering the drying chamber has naturally a tendency to rise at once to the top, and it is found that beans on the uppermost tier of trays dry perfectly in thirty-six hours, whilst those on the lower tiers take a longer time. In all other respects, provided the fan is kept constantly revolving, a drier constructed on the Ceylon principle gives fairly satisfactory results.

Last year Mr. Frederick Harford erected a "drier" at L'Esterre estate on designs furnished by the Blackman Ventilating Co: of London. In this drier an attempt is made to force the hot air through the drying box by reversing the action of the fan and placing it immediately over the furnace. In all other respects the arrangements of the Blackman

machine are the same as those already described in the case of the Ceylon drier. The results obtained with this machine in the first instance were not satisfactory, and great difficulty was experienced in forcing the hot air through the entire length of the drying chamber. This difficulty has now been met by placing another (an exhaust) fan at the end of the drying box farthest away from the furnace. The high cost, however (about £300), of this drier places it beyond the reach of small cultivators.

From what has been stated it would seem that a cacao drier constructed on the principle of that in use in Ceylon, is the one most likely to give satisfactory results in the West Indies. In order, however, for it to do so, care must be taken to confine the hot air on entering the drying box within a well defined channel. This should be so arranged as to permit of the hot air passing over the lowest tier of trays first; it should then be carried in a serpentine manner over and around the upper tiers in succession until it finally passes out at the point where the exhaust fan is placed.

A cacao drier, the drying or inner box of which measures twenty feet by eight feet with a depth of eight feet, combining the arrangements above indicated is proposed to be erected by the Imperial Department of Agriculture at the Botanic Station, Dominica. The following is a brief description with diagram:—



The drying box, as above shown, is divided into three compartments: "A" "B" "C." The divisions between these (indicated by continuous lines) are so arranged that the hot air is compelled to pass successively through them in the direction indicated by the arrows. On rising from the stove, the hot air first enters chamber "A" where it passes over and under the cacao beans which are spread on trays (shown by dotted lines); thence it passes in turn through chambers "B" and "C"

through the openings "E" and "F" and is finally drawn out at "G" by the exhaust action of a fan worked by hand. The trays are fixed on wheels which permit them to be drawn out into the cacao house from time to time for the purpose of stirring or removing the cacao. With the view of testing the action of wire as compared with bamboo or wooden laths on the wet cacao beans the tray in chamber "A" will be constructed of rather stout galvanised wire netting, that in "B" of split woven bamboo, and that in "C" of thin wooden laths. The fan (18 in.) has been obtained from the Blackman Ventilating Co, of London, and the stove (Mott's "Comet" No. 28) from I. L. Mott of New York. The latter is surrounded by a galvanised iron jacket to confine the hot air and to discharge it through a cowl into the cacao drier. The chimney of the stove, not shown in the diagram, is entirely outside the building.

"THRIPS" ON CACAO TREES.

The following correspondence is reproduced for the purpose of affording information in regard to a somewhat obscure but not yet serious disease affecting cacao trees in the West Indies.

Imperial Commissioner of Agriculture—to Acting-Colonial Secretary, Grenada.

Barbados,
December 13, 1900.

Sir,

With reference to former correspondence, on the subject of the occurrence of what is known as the "thrip" disease on cacao estates in Grenada, I have the honour to forward herewith a copy (in duplicate) of a report prepared by Mr. H. Maxwell-Lefroy after his recent visit to the island.

2. It is evident that Mr. Maxwell-Lefroy devoted himself with great energy to the task entrusted to him and I have no hesitation in stating that his report is a valuable contribution to the study of this somewhat intricate subject.

3. As I anticipated, it is not yet quite clear how far the "thrips" is entirely responsible for the unsatisfactory condition of the cacao trees in some districts of Grenada. Mr. Maxwell-Lefroy states (paragraph 4) "that in many cases this is due to some other cause than "thrips." Further, it is his conviction "that in the majority of cases "thrips" is not the cause of serious damage to the trees or of short crops." These may be due to special causes operating in each case, and not to the prevalence of any particular disease in the island.

4. In cases where "thrips" are abundant and where serious harm is done by them, I recommend that the remedies suggested by Mr. Maxwell-Lefroy be fully and carefully tried. Further, I suggest for consideration, as a last resource, and in case the "thrips" is found to spread generally in the island, whether some of the provisions of the "Agricultural Interests

Protection Ordinance, 1900" might not be judiciously and gradually put into operation.

I have, &c.,

(Sgd.) D. MORRIS.
Commissioner of Agriculture for the West Indies.

Mr. H. Maxwell-Lefroy, Entomologist—to Imperial Commissioner of Agriculture.

Barbados,
December 8, 1900.

Sir,

I have the honour to submit a report of a visit paid to Grenada from November 27 to December 7 to investigate the injury alleged to have been caused to cacao estates by "thrips" and other insects.

2. The cacao is suffering from damage in four distinct ways:—(*a*) the leaves of the young trees are attacked, leading to the death of badly attacked plants; (*b*) the leaves of the older trees are attacked; (*c*) the young pods are attacked, and their development arrested or retarded; (*d*) the mature pods are attacked.

(*a*) Young trees suffering from the attack of "thrips" were seen at two localities only. "Thrips" were found in considerable numbers on the leaves, which turn brown and drop off. The young trees have a sickly appearance, the deep green colour of the leaves of vigorous cacao trees being absent. Comparatively little damage appears to have resulted from this form of attack up to the present, but, should this increase, the prospect would undoubtedly be more serious than it is at present.

(*b*) The leaves of trees in full bearing are commonly to be found with "thrips" on them. In only two instances have I seen any considerable proportion of the leaves attacked, and as a rule, this form of damage appears to be very slight. It is a matter of considerable difficulty to say whether "thrips" is responsible for any serious damage to the leaves of the bearing cacao trees, but I am of opinion that in one case only is the evidence sufficient to justify the statement that "thrips" seriously injures the leaves of large trees.

(*c*) Young pods attacked by "thrips" so seriously as to have their development checked have been seen in one case only. Apparently when large numbers of "thrips" attack a small pod, its growth is checked; it becomes brown and shrivels up. Pods so attacked must not, however, be confused with the large number of small black pods which are found commonly on the trees. I have been informed that when half-grown pods are attacked by "thrips," they as a rule, mature, but a longer period is needed before they are fully ripe. At

the present time there appears to be very slight cause for apprehension from this form of attack.

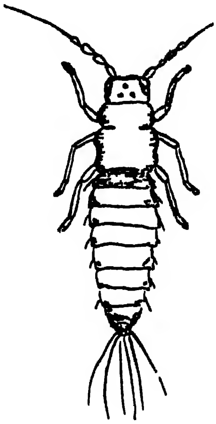


Fig 1.
Young "Thrips"

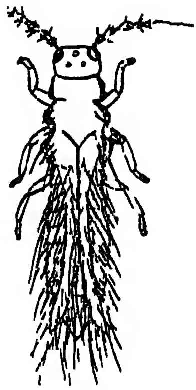


Fig. 2.
Mature "Thrips."

(*d*) The most general form of attack is that in which the pods are turned to a deep brown colour as they mature. This can be seen on every infested estate, and it does not appear to be injurious to the pods, or a serious form of attack. This brown colour is associated with "thrips," but the actual cause is not apparent. The young stages of "thrips" carry a drop of brown liquid at the hind end of the body. This they deposit on the pods and these drops, when dry, are in the form of brown flakes. These brown flakes are characteristic of the presence of "thrips" but are not the cause of the brown colour of the pod. The mahogany-brown colour of the pod is due to the colour of the contents of the cells of the skin of the pod, and it must be remembered that this brown colouration of the skin of the pod is produced in the pod itself. It is difficult to tell from the external appearance of such a pod whether it is ripe or not. If the pod is left too long on the tree, the contents are said to be worthless, and equally so, if the pods are picked before they are ripe. In this way, the brown pods are a source of loss to cacao planters, as a larger or smaller number of the pods picked are liable to be worthless.

3. The actual damage caused by "thrips" has been discussed in the preceding paragraph, and the present condition of things in Grenada may now be summed up:—

"Thrips" is certainly responsible for damage, and usually to the mature pods; in the majority of cases, no further destruction can be confidently assigned to this insect. On several estates the trees are in a sickly or diseased condition, and, in a few instances, appear to be dying. In a few cases the trees are not producing a normal yield of pods, and the crop is either very much diminished or likely to be so in the future. The majority of those cases have been regarded as instances of destruction caused by "thrips" and, in some cases, this appears to have been stated without regard to the presence or absence

of the insect in question. I am of opinion that in many cases this serious damage is due to some cause other than "thrips." I am unable to say to what it is due, but the evidence tends to show that "thrips" is the cause of little damage beyond injury to the mature pods. In one instance that I observed, the trees had few pods and there was an almost entire absence of blossoms or developing pods. This patch of cacao was instanced as the place where "thrips" was working its most serious harm, but careful examination showed that not only was the insect almost entirely absent from that part of the estate, but there were no indications that any "thrips" had been there in the immediate past. I do not wish to under-rate the injury caused by "thrips" to young trees or pods, in a very small number of cases, but it is very desirable that, where some other cause has led to a diseased condition of the trees, this should be recognized. The mere presence of small numbers of "thrips" should not be accepted as proof that to it must be assigned the death of a tree. I have been informed that the condition of the trees in the parish of St. Andrew may be due to a partial drought during the years 1898 and 1899. Though the actual rainfall during 1898 and 1899 was low in St. Andrew's (73 and 70 inches) and higher in the two previous years (100 and 92 inches), the relative humidity for 1898 and 1899 is described as "medium," and for 1896 and 1897 as "bad" and "good" respectively. (Colonial Secretary's Report on the Grenada Blue Book for 1899). The deficiency in rainfall and humidity during the two seasons preceding the present one is not sufficient to account with certainty for the damaged trees. There may be some fungoid disease, some condition in the soil, in the manuring, or in the treatment of the trees that has brought them to the present bad state, but I am unable to state more than my conviction that in the majority of cases "thrips" is not the cause of damage to trees nor of short crops.

During my visits to estates, I have observed the very frequent occurrence of large quantities of lichens and other vegetable growths on the trunks of the cacao trees. I have also constantly noticed that the pruning of the trees is carried out in a way that appears calculated to induce disease. With regard to the possibility of the presence of some fungoid disease on the dying trees, examination of the trees by an expert would be needed, and I am not able to speak with any certainty; no decisive indications of such disease were noticed, and I saw no reason to accept a fungoid disease as a possible explanation of the bad condition of the trees in the parishes of St. Andrew and St. David.

4. The "thrips" that attacks cacao is also found apparently upon the cashew tree, the guava and the Liberian coffee.

The cashew is especially attacked and loses its leaves when large number of "thrips" are found. No other plants were found to be attacked by what I regard as "cacao thrips" though other species of "thrips" may be found on cultivated plants.

5. The remedies to be adopted for this disease must depend on the extent and nature of the injury done by "thrips." At present, no remedy will be found actually necessary in the

majority of cases. The damage is solely to the pods, and is so slight that it will not be worth while adopting any remedy for the present damage. It is impossible to say whether the disease is likely to increase or not; but with regard to the future it may be useful to take simple precautions against the spread of the disease. The remedies advocated are:—

(*a*) Destroy the insects on the pods when they are picked. At present pods with numbers of insects are picked; the beans are extracted, and the shells left on the ground in heaps. On these heaps, the young "thrips" may complete their development, and, when matured, can fly away. This should not continue: the shells should be at once *buried*, *burnt* or *scorched*, or covered with lime. This must be done as soon as possible after the pods are picked.

(*b*) Destroy the insects on the pods before the pods are ripe. This will not be so easy or so inexpensive as the first remedy. The pods will need to be painted or sprayed with either kerosene emulsion, rosin wash or some similar wash. The insects on these pods will then be killed, and others will be deterred from attacking these pods. On some estates, at the present time, kerosene emulsion, or lime and kerosene are being used in this way.

This remedy will be specially valuable to protect young pods. Until it has been carried out on a large scale, the cost cannot be estimated. I would most earnestly recommend that on the arrival of the proper appliances and the materials for preparing rosin wash, a thorough trial be made of this remedy under the directions of some skilled person. I regard this remedy as likely to prove of very great value should the disease extend or become very serious, and trials should be made of it without delay.

(*c*) In cases of damage to young plants, it will be necessary to spray the under-sides of the leaves with rosin-wash or kerosene emulsion. This will first need to be tried in order to find the strength of mixture that will destroy the insect and not hurt the tender leaves.

(*d*) In cases of very serious damage to old trees, it will be necessary to spray the leaves from below. This remedy will be expensive, and is not likely to be resorted to till the damage has reached a very serious pitch.

(*e*) Destroy all plants that are found to serve as food-plants for cacao "thrips." This also need not be considered at the present time, as the damage is not sufficient to justify such an expenditure. As an alternative (*f*) Use the cashew and other food-plants of cacao "thrips" as traps for "thrips." If cashews are more attractive than cacao to the "thrips" those at present growing near the cacao trees might be used as traps. The "thrips" on them would need to be periodically destroyed either by spraying, or perhaps better, by burning sulphur below the trees. If the trees are sprayed, "thrips" are unlikely to return for a considerable time. But if the insects could be destroyed by means of smoke, then a fresh batch might attack the cashew within a short time and could in turn be destroyed.

6. The remedies considered above are rather possibilities than actual recommendations. I am of opinion that at the present time the damage is not such as to warrant any considerable expenditure. I consider it eminently desirable that a thorough trial be made of the efficacy and costliness of the treatment with rosin wash. This wash is recommended as better than kerosene emulsion on account of the smaller cost of the mixture. When a trial has been made of this treatment, it will be possible to decide whether it is likely to pay to adopt it. Apparently cacao "thrips" is increasing in numbers, and has appeared on a number of estates. Should it continue to increase in this way, it will be better to spend a comparatively large sum upon its destruction. In such a case the provisions of the "Agricultural Interests Protection Ordinance 1900" will need to be enforced, and the destruction of "thrips" undertaken systematically throughout the island. I am of opinion that at the present time it is necessary to wait, with a view of judging whether the pest is on the increase. Every one interested in cacao should make sure of the condition of their trees as to whether the pest is found on them or not. Only by the careful observations of those who are constantly among the cacao trees will it be possible to judge whether this disease is becoming more serious. So long as the attack is chiefly confined to the mature pods, little anxiety need be felt, and active remedies are little likely to profit. But when it is found that the young trees are being killed, or that the pods are attacked when they are quite young, and when this is not the exception, but the rule, it will be time to consider how best to combat the disease on a large scale. The pest will then assume first class rank, and a more extended investigation will be desirable. At the present time, observation is needed, and the cacao planters of Grenada may feel that there is no cause for immediate alarm. It is possible that the pest may disappear, or becomes less abundant from natural causes, and it is also possible that a natural enemy of "thrips" may make its appearance.

I have, etc.,

(Sgd.) H. MAXWELL-LEFROY,
Entomologist.

Imperial Commissioner of Agriculture—to Governor-in-Chief of the Windward Islands.

Barbados,
March 25, 1901.

Sir,

In continuation of my letter, dated the 4th instant, I have the honour to forward, herewith, a copy, in duplicate, of a further report prepared by Mr. Maxwell-Lefroy on the

present position and prospects of the attack of "thrips" on cacao trees in Grenada.

2. As Your Excellency is aware, this has been the subject of careful attention by the officers of the Department. I visited the island myself from the 23rd. to the 28th. of February last, and consulted personally most of the planters directly interested in the matter.

3. Mr. Lefroy's present report is, in my opinion, a valuable contribution on the occurrence of "thrips" in Grenada, and deals practically and usefully with the subject.

4. It also places very clearly before the planters the means likely to be successful in dealing with the pest and gives detailed information relative to spraying machines, washes and general treatment of the trees.

5. A report by Mr. Albert Howard on certain fungoid parasites observed by him on cacao trees in Grenada is in course of preparation. In the meantime I would repeat what I stated in my letter of December 24 last, as to the necessity for taking greater care in pruning cacao trees, in burying all diseased pods and in maintaining the most favourable conditions for the healthy growth of the trees.

I have, &c.,

(Sgd.) D. MORRIS,
Commissioner of Agriculture
for the West Indies.

Mr. H. Maxwell-Lefroy, Entomologist—to Imperial Commissioner of Agriculture.

Barbados,
March 21, 1901.

Sir,

I have the honour to submit a report of a visit paid to Grenada from the 5th. to the 15th. of March, to continue the investigation into the "thrips" on cacao.

The objects of this visit were, shortly, to study the present position of "thrips," to examine the effect of the spraying already carried out, to test the practical value of this remedy, and to make any further observations on this insect.

SPRAYING IN JANUARY AND FEBRUARY.

Spraying has been carried out during January and February at the Botanic Station, Tempè, Good Hope, Grand Bras, Cardrona, and Grenville. The cacao trees at the Botanic Station received, some two, some three doses of rosin wash. The trees elsewhere received one dose only. So far as can be determined the trees at the Botanic Station have benefited very

considerably by the treatment. In December these trees were infested with "thrips" in all stages, as are the unsprayed trees at the present time. The sprayed trees now contain very few "thrips," and it is possible that these have come from the neighbouring unsprayed cacao, as the few insects I saw were mature.

The trees outside the Botanic Station which have been sprayed, were carefully examined. In all but one case, they are almost clear of "thrips" and compare very favourably with the neighbouring unsprayed trees. It is not possible to say more than this, as I am not sufficiently acquainted with their condition before spraying. One patch of 140 sprayed trees is now infested with "thrips" in all stages. I am at a loss to account for this, unless the treatment was very negligently carried out. Excluding this isolated case, and bearing in mind the fact that the sprayed trees received only one treatment and are surrounded with unsprayed trees, I am of opinion that this treatment with rosin wash has been distinctly beneficial in reducing the numbers of "thrips."

SPRAYING IN MARCH.

During my visit spraying was carried out at the Botanic Station, Grand Bras, L'Esterre, Brothers, and Grand Roy Valley. This was done with the object of testing the practical value of this remedy and of showing the method of treatment. Those who witnessed the spraying and had opportunities of seeing the effect on the trees, will be able to form their own conclusions as to the efficacy and practicability of the remedy. The sprayed trees at the Botanic Station are open to examination by any person who is interested in the results of this treatment. The washes applied were (1) rosin wash, (2) kerosene emulsion and (3) whale oil soap; only the knapsack spraying machines were used.

PRESENT POSITION.

The present condition of the "thrips" appears to be much the same as it was in December of last year. They were found on all the estates I visited, both on the leaves and on the pods. In some cases a few pods only were attacked. In one case every pod on three acres of well established cacao appeared to be affected, and in a few cases both leaves and pods were attacked. No definite case of actual damage referable to "thrips" came under my notice. I am still unable to say that "thrips" causes direct damage to cacao at the present time. The fact of its occurring abundantly on mature pods leads apparently to loss, owing to the fact that unripe pods are picked for ripe ones. The damage due to this has been estimated at one-third of the crop in bad cases of "thrips" attack, but I am unable to form any opinion on this matter. It is asserted that there need be no loss from "rusty" pods, as I am informed the picking gangs can, by scratching the skin, discover whether the pod is ripe. There appears to be a difference of opinion on this point and no satisfactory conclusion can be arrived at. The "thrips" appears to have increased in numbers in some

places, and decreased in other places. Local conditions may cause this to take place in different parts of the island, and there does not seem to be any evidence either of distinct general increase or decrease in the numbers of "thrips" since December of last year.

PROBABLE ORIGIN OF "THRIPS" ON CACAO.

The insect occurs at present generally distributed throughout the parishes of St. George, St. David, St. Andrew and St. John. I am informed that it also occurs generally in St. Mark and St. Patrick. It is found on the leaves and pods of the cacao, and on the leaves of cashew, guava and Liberian coffee. It is known to occur also on cacao in St. Vincent, St. Lucia and Dominica, but is not known to have been found in any other part of the world.* It is reasonable to suppose that this insect may have lived on the wild guava and cashew in these islands before the first cacao was planted. As the land was brought into cultivation, the amount of its native food plants grew less with the increasing number of established cacao trees. There is now a very large area under cacao, and this insect, having once accustomed itself to its new food plant, has thriven abundantly under such favourable conditions. It appears to have increased, and spread through the cacao trees till at the present time, it is found practically throughout the island. It seems reasonable to suppose that this may have been the sequence of events in the past and may account for the present large numbers of the insect. "Thrips" is specially favoured in many ways; its small size is probably sufficient to protect it from lizards or birds. Its powers of flight, when fully mature, enable it to move from tree to tree with ease. It finds an abundance of its food plant combined with an absence of wind and sun that may assist its increase very materially.

PROSPECTS OF "THRIPS."

There are three possibilities to be borne in mind as to the future of the insect.

(1) It may, under the influence of adverse circumstances, decrease in number and almost disappear. This happens in nature from no reason that can be easily understood, and it is possible that "thrips" may grow less from natural causes, as it has increased. Natural enemies would play a large part in this case, but, so far, no insects have been seen to feed upon "thrips." Yet the numbers of the insect in some localities show a very marked diminution since December of last year;

(2) The insect may remain as it is at present. In that case little need be done against it, and it is probable that trees in vigorous health will never suffer appreciably from the attacks of "thrips;"

(3) The insect may increase in numbers. In this case, remedies will sooner or later have to be employed against it, and

* A "thrips" disease of cacao has recently been under investigation in Ceylon. It is apparently not due to the same "thrips" as occurs in the West Indies. [Ed. W.I.B.]

if good results are to be secured these remedies must be universally adopted. Whatever remedy is adopted the labour of applying it on every acre of cacao in Grenada will be very considerable. There is no indication at present that such a course is likely to become necessary. In one instance only have I seen so much "thrips" as to warrant the adoption of a direct measure to destroy it and in this case spraying would be amply sufficient to secure the object aimed at.

It is very much to be desired that the progress of this insect should be carefully watched in Grenada. An undue amount of stress has in the past been laid on the destructive character of the insect. It is never easy to assign the destruction of a plant to its right cause. There have been short crops, some trees have lost leaves, and the pods do turn brown. But this cannot with any just reason be *all* assigned to "thrips"

If a short crop is produced concurrently with the appearance of "thrips," it is not possible to say without further investigation that the one is produced by the other.

There is now a great necessity for well balanced judgement regarding the part played by "thrips" in Grenada, and, while not wishing to treat the matter lightly, I would urge the necessity of very careful examination of all the facts before the conclusion is arrived at that "thrips" is causing serious damage to cacao. If it is found that the numbers of "thrips" increase, and that the young plants or the pods suffer from its attacks, well organised measures will be necessary to secure the destruction of this insect. But the damage must become very obvious and amount to a considerable total before it will be reasonable to undertake a serious campaign against this insect.

PRESENT RECOMMENDATIONS.

At the present moment, there is little that can be done against "thrips." The trees must be kept in as vigorous a state as possible; the greatest attention should be paid to keeping the land in good condition, to maintaining the trees clear of parasitic plants, to good pruning and to checking the ravages of the cacao beetle. A weak plant is far more liable to suffer from the presence of "thrips" and is probably a direct encouragement to "thrips." Where it is evident that a very great number of "thrips" are found on the pods, these pods can be easily treated with the spraying machine. I have seen only one case where I should at present advise this to be done.

If cashew trees, planted as wind-breaks in or near cacao, are badly affected, it may be wise to spray them or to cut them down. I am not at present aware of any other precautions that can be adopted with advantage, nor do I see good reason for entertaining serious apprehensions with regard to the damage likely to be caused by this insect.

GENERAL TREATMENT.

In the event of the necessity arising for general treatment throughout the island, spraying appears to be the only satisfactory remedy. It will be necessary to spray systematically over

the whole of every estate and small holding, not omitting a single tree; the wild guava will have to be destroyed wherever possible, and cultivated guava, cashew and Liberian coffee must equally be sprayed or destroyed. It will not be sufficient to treat an estate here and another there, omitting the intervening portions for a time; the work should be done systematically from one or more points, and proceed methodically until the whole area has been thoroughly treated. Such an undertaking will require very careful organisation and the provisions of the "Agricultural interests Protection Ordinance" may require to be strictly enforced.

SUMMARY.

It may be of use to shortly sum up the present position of "thrips" in Grenada. "Thrips" may be regarded as a possible enemy to cacao, rather than as an actual pest. There does not appear to be any serious cause for alarm at the present time and the chance of the cacao suffering materially from the attack of this insect is, in my opinion, remote.

Careful observation on the part of those interested in cacao with sustained efforts to maintain the trees in as vigorous a condition as possible is the prime necessity at the present time. If in the course of time "thrips" does become an unmistakable pest the planters of Grenada may then consider whether it is necessary to undertake the treatment discussed in the Appendix. It is not possible to suggest any further steps that can be taken at the present time and it would be well to wait until the existing condition of affairs alters for the better or for the worse. Should any feel disposed to check the numbers of the "thrips" at once, the materials for spraying are already prepared and spraying can be undertaken without delay. Extended observation of the thrips by those who are constantly among the cacao may lead to the discovery of natural enemies or throw further light on the subject of this insect.

I have, etc.,

(Sgd.) H. Maxwell-Lefroy,
Entomologist.

APPENDIX.

This appendix contains full directions for carrying out spraying, and these particulars, obtained from the recent experiments, will enable any one to estimate the probable cost of the treatment, should it any time become necessary to adopt it on a large scale. An approximate estimate derived from these data is given under "Cost of Treatment."

WASHES.

Experience has shown that, as with other insects, there is a considerable choice of washes, and, though rosin wash is the

best for general work, equally good results may be obtained from using other washes under special circumstances. The formulæ for preparing five washes are here given.

Rosin Wash.

Powdered Rosin	4lbs.
Caustic Soda (77 per cent.)	1lb.
Fish Oil	½ pint.

Mix these, cover with about two inches depth of water and boil till all is dissolved. Then add water, *very slowly*, to the liquid, keeping it continually boiling until the whole is made up to about 3 gallons. This is stock solution. For use, add 6 gallons of water to one gallon of stock solution.

Amount of wash 21 gallons.

Rosin Compound.

Powdered Rosin	1lbs.
Washing Soda	3lbs.

Mix, cover with about two inches depth of water, and boil till all is dissolved. Then add water, very slowly, continually boiling the mixture, until it amounts to 4 gallons. If the mixture is then very thick, it must be boiled until it becomes a clear brown colour, easily stirred. This is stock solution. For use, add 6 gallons of water to one of stock solution.

Makes 28 to 30 gallons of wash.

Kerosene Emulsion.

Hard Soap ..	½ lb.
Kerosene	2 gallons.

Boil the soap in one gallon of water till it is dissolved. Take it off the fire, *at once* pour in the kerosene, and churn the mixture with a force pump or syringe for 10 minutes. This is stock solution. Add 9 gallons of water to one of the stock solution.

Makes 30 gallons.

Rosin and Whale Oil Soap Compound.

Rosin	1 lbs.
Washing Soda	3 lbs.
Whale Oil Soap	10 lbs.

With the rosin and soda make 4 gallons of rosin compound stock solution as above. Stir the whale oil soap in 5 gallons of hot water; mix the two while hot. This is stock solution. To every gallon add 4 gallons of water. An alternative method is to make the rosin compound stock solution; for use, mix 1 gallon with 10 gallons of water and stir in 2½ lbs. of whale oil soap. Every 45 gallons of wash should contain the above ingredients, however mixed.

Whale Oil Soap.

Whale Oil Soap	1 lb.
Water	2 gallons

Mix and stir well.

In calculating these washes, care has been taken to enumerate in every case such amounts as will make so much stock solution as can be prepared in a kerosene tin. Kerosene tins are very convenient for preparing stock solution for 20 to 30 gallons of wash. The above formulæ are not rigid: the washes can safely be made somewhat weaker or stronger without impairing their efficacy, and as long as ordinary precautions are taken to insure accuracy in mixing and boiling, good results should in every case be obtained. It is necessary to use water that is not impregnated with lime, or mineral salts. Wherever possible it is best to use rain water, and this is of special importance in preparing kerosene emulsion and rosin wash. Failures are sometimes due to slow boiling; in making washes, the liquids should boil briskly, and the mixture can then be made more safely and expeditiously. The materials mentioned above can be obtained at Grenada at the present time. Rosin, caustic soda and whale oil soap have been imported and are to be sold at cost price at the Botanic Station. Washing soda, kerosene, hard soap and fish oil can be obtained at St. George's. Whale oil soap can also be obtained from Barbados through Messrs. H. E. Thorne & Son at 10 cents per lb. in small quantities, and 8 cents per lb. in large lots exclusive of packing, etc. This soap is originally obtained from the maker, James Good, 941. North Front Street, Philadelphia, P.A. It is known as "Good's No. 3 Caustic Potash Whale Oil Soap," and is sold as follows:-

50 lbs.	@	5	cents	per	lb.
100	,, ,,	4½	,,	,,	,,
170	,, ,,	4	,,	,,	,,
half barrel 270	,, ,,	3½	,,	,,	,,
barrel 400	,, ,,	3¼	,,	,,	,,

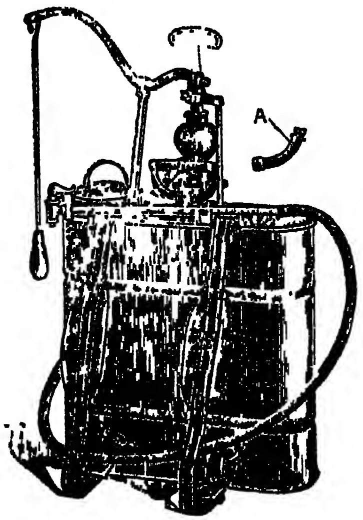
There is a certain amount of difference in the action of the washes enumerated above. Rosin wash is apparently the best wash for general work. It is practically a solution of rosin soap and fish oil soap. It has one disadvantage in the fact that caustic soda does not keep well. This chemical is imported in iron drums, and cannot be left exposed to air but must be kept in a closed metal vessel. In making wash on a large scale this is not a real disadvantage as the soda can be imported in drums. Rosin wash is a durable and effective mixture likely to be of more lasting effect than washes not containing rosin. Rosin compound has not been tested on "thrips" but is mentioned as it is easily made, though it is not so powerful, as a rule, as other washes. It is efficacious against similar forms of insect diseases and deserves a trial. Kerosene emulsion is a very good wash for temporary effect. Both the soap and kerosene soon disappear. I would recommend this especially for freeing developing pods of "thrips" and in cases where a lasting effect is not aimed at.

Whale oil soap is, like kerosene emulsion, easily washed off but is very effective. It appears to be a more successful remedy than kerosene emulsion, possibly on account of the fish oil, and has the very great advantage of extreme ease in preparation, requiring no heating or preparation of stock

solution: the soap, which is semi-liquid, is simply stirred in water. Rosin and whale oil soap compound is a mixture practically of rosin compound and whale oil soap, and combines the deadly qualities of the fish oil with the lasting powers of the rosin. It has not been tried against "thrips" but is especially effective against other sucking insects. For those who have no wish to try any wash that has not already been tried on "thrips" I would advise rosin wash for general work, kerosene emulsion for spraying only developing or mature pods.

MACHINES.

The "Success" knapsack spraying machine was found to be well adapted for the conditions obtaining in Grenada, capable of application wherever cacao is grown.



THE "SUCCESS" KNAPSACK SPRAYER.

A knapsack sprayer and bucket sprayer combined with a five gallon copper tank to hold the liquid which is applied in a mist-like spray.

A machine can be manipulated by one *experienced* man, but two men are necessary at first. There is no special knowledge or skill requisite; the machines are not liable to get out of order and a large number of men could be shown how to manipulate the machines in one day. The "Success" knapsack spraying machine is manufactured by the Deming Company, Salem, Ohio. It is obtainable direct from Peter Henderson & Co., 35, Cortland Street, New York, for $11.00 complete. It will be advisable to keep a spare length of the india-rubber hose, as rubber deteriorates very rapidly in a warm climate. This hose costs 20 cents per foot. In purchasing a machine, it is necessary to specify the "Bordeaux" nozzle, which is the most important part of the machine. These machines hold 5 gallons of liquid. It will be necessary to constantly refill these machines when they are in use. This can be done most conveniently by means of a barrel fitted on wheels. The stock solution can be carried to the spot in kerosene tins. The barrel, full of water, can then be brought from the nearest stream and the wash mixed in the barrel. A very light water barrel truck can be obtained from Peter Henderson and Co., 35, Cortlandt Street, New York, for $9. Any barrel can be fitted to this very easily, and by using a 4 foot length of rubber hose as a syphon, the knapsack machines can easily be filled.

RATE OF WORK.

It was found that two men could do, working regularly, an average of forty trees an hour, spraying the leaves and pods.

Allowing time for mixing the wash (stock solution and water) and carrying the machine to the trees to be sprayed, a fair estimate of a day's work with one machine and two inexperienced men would be half an acre. Very old trees take longer to do and young trees can be done more rapidly but this figure represents the average amount that should be done with inexperienced men, working 7 hours a day.

AMOUNT OF WASH.

The amount of wash used is not very large : one gallon is ample to do four trees, spraying leaves and pods. This figure is the average of a large number of trees, taking all well established trees. Rather more than 100 gallons of wash would be necessary to do one acre of cacao.

COST OF WASH.

The cost of the materials used can be fairly approximately estimated ; the following figures give the cost per 100 gallons of the different washes as calculated from the price of materials in Grenada :—

Kerosene Emulsion	\$1·66
Rosin Wash	\$1·14
Whale Oil Soap	\$2·25
Rosin Compound	\$1·20
Rosin & Whale Oil Soap Compound ...	\$1·80

Kerosene emulsion is calculated from the actual price of the materials in Grenada. Rosin wash is the actual cost of the wash as prepared at the Botanic Station from materials imported from England. Whale oil soap per barrel of over 400 pounds costs in New York 3¼ cents per pound. Freight brings the cost to 4½ cents per pound. Rosin compound is calculated from the price of the imported rosin and the price of local washing soda.

COST OF TREATMENT.

It is now possible to get some estimate of the cost of spraying an acre of cacao : two men are needed for two days : 100 gallons of wash will be found sufficient in very nearly all cases. Fuel, kerosene tins or larger vessels for boiling the mixture, and the machines are the only further items, and a reasonable estimate of the total cost can be obtained. In addition to the labour and the cost of the wash there is the labour in making stock solution and the supervision. It will be necessary to calculate the total cost for a gang of say ten men working at once with five knapsack machines and a man to make stock solution. In a week then the expenses will be :—

10 men at 30 cents daily	\$18·00
1 man at 24 „ „	\$ 1·44
1,500 gallons Rosin Wash	\$17·10
Supervision	\$ 5·00
	\$41·54

These men will do an area of 15 acres working regularly; the cost per acre then under these circumstances will work out at a figure close to $3.00 per acre for one treatment. As in all probability the treatment must be repeated after a week to secure the best results, the total cost will amount to $6·00 per acre.

Initial expenses will be as follows:

5 Knapsack machines	...	$55·00
5 lengths of spare hose, 1ft. long	...	$ 1·00
1 barrel	...	$ 1·00
1 truck	...	$ 9·00
		$69·00

In addition there will be the freight on the machines and the cost of the vessel used for boiling the mixture. The above figures are approximate, but they may be sufficiently near to give a fair idea of the probable cost of spraying cacao on a large scale.

The staff at the Botanic Station has been instructed in preparing these washes. I would recommend that as a demonstration the trees of the Botanic Station should be systematically sprayed with these mixtures. The mixtures should be prepared and applied on one day in every week, and this should be notified so that persons interested could not only be able to see the washes prepared but also to see the machines at work. The trees at the Botanic Station need careful spraying to keep them clear of the blights that attack them, and this might be done regularly in this way, as a demonstration, until all scale insects, mealy bugs, etc. have been destroyed.

(Intld.) H. M-L.

THE FUNGOID DISEASES OF CACAO IN THE WEST INDIES.

BY ALBERT HOWARD, B.A., A.R.C.S., F.L.S., F.C.S.

Mycologist and Agricultural Lecturer to the Imperial Department of Agriculture for the West Indies.

Of late years the production of cacao in the West Indies has materially increased, and at the present time considerable areas are being planted with this crop in several of the islands. Cacao has almost completely replaced sugar in Grenada, while in Trinidad, British Guiana, St. Lucia, Dominica, and to a lesser extent in St. Vincent, it forms an important article of export the value of which is increasing every year. As in the East so in the West Indies, fungoid diseases have made their appearance and will be a factor to be dealt with in the cacao cultivation of the future in these Colonies if the greatest possible returns are to be secured. The losses suffered now are consider-

able but, on account of the large profits made on many cacao plantations, are frequently overlooked and sometimes perhaps disregarded, being looked upon as a part of the regular order of things. Should however, as seems likely, the production of cacao increase more rapidly than the demand, the resulting fall in prices must compel planters to take measures to prevent these losses on their estates and to make up by increased production for the diminished value of their staple. Some of the apathy shown by planters in the past, especially by the small holders, towards the damage done to their properties by fungoid diseases is no doubt due to the popular idea that these diseases are caused either by the sun, some unsuitable condition of the soil, or by the tap-root having come in contact with a flat stone or some impervious stratum beneath the sub-soil. Under these circumstances it is not surprising that nothing has been done in many cases to deal with these diseases, since, if the above causes of the disease were the true ones, human agency could do little in the way of successful treatment. A correct knowledge of the real causes of the trouble however, is slowly spreading, and several planters in the various islands are paying attention to the subject and conducting their cultivation in such a manner as to reduce the risk of fungoid attack to a minimum.

The diseases of cacao in the West Indies have recently been the subject of considerable investigation by the Imperial Department of Agriculture for the West Indies, and an attempt is made in the present paper to give an account of the work already done and also to bring together some of the results of other workers on the fungoid diseases of cacao. As will be seen in the following, much work still remains to be done to complete our knowledge of the life-histories of these pests and to find out the best means for their suppression.

For the sake of clearness the diseases are grouped under (1) Pod diseases, (2) Stem diseases, and (3) Root disease.

POD DISEASES.

One of the striking features of the cacao tree is the enormous number of small pods which shrivel up and drop off the tree, without being attacked by any definite disease. It is true that these small pods are, especially when dead, covered with fungoid growths, but these are principally saprophytic in nature. The phenomenon is doubtless identical with that noted in other trees when a larger number of fruits are produced at first than can be brought to maturity by the tree. It would appear that the number of pods which reach maturity depends on many factors, such as the variety of the cacao tree in question, the rainfall, the available minerals, as well as the other factors which influence growth and bearing power. The subject has received some attention in Ceylon (28) where the pollination of the cacao flower is being studied in the hope of producing an increased yield. The matter, as yet, does not seem to have received attention in the West Indies.

Up to the present, three distinct pod diseases have been noted in the West Indies, one of which is widely distributed in

the various islands and occurs probably also in Ecuador, while the other two appear to be almost confined to Trinidad.

"BROWN ROT" DISEASE OF THE POD.

(*Diplodia cacaoicola*. P. Henn.)

Although this disease has doubtless existed in the West Indies for years, no investigation as to its nature appears to have been made before the present year, when the writer visited Grenada for the purpose of reporting on the nature and extent of the fungoid diseases attacking cacao in that island. Subsequently the disease has been noted in St. Lucia, St Vincent and Dominica.

General Characters.

When cacao pods are attacked by this disease, a circular brown patch makes its appearance which gradually extends all over the pod and causes complete destruction of the rind and its contents. The time taken in the destruction of a pod varies somewhat according to its ripeness, but usually falls between six and ten days from the appearance of a diseased spot visible to the naked eye. This appearance must not be confused with the rusty or "mahogany" pods which result from "thrips" when the whole of the outside of the pod takes on a rusty colour but when the rind is not diseased.* The definite brown patches in question generally commence either at the insertion of the stalk or at the free end of the pod, but they may occur at other points, especially where the rind has been injured or where the pod comes in contact with a branch. These diseased pods are particularly numerous near the "breaking-grounds" where the beans are extracted by the pickers. If one of these attacked pods is carefully examined it will be found that the brown area is rotten and that the decay extends to and spreads round the shell of the pod to a much greater distance than would be supposed from a surface examination. The disease soon spreads to the "beans" which are speedily attacked and destroyed by a greyish fungus mycelium which grows with enormous rapidity in the mucilage surrounding the seeds, and eventually dries up the whole contents of the fruit, and gives to it a curious sour smell.

Microscopic Characters.

Microscopic examination of the tissues of the brown area shows that the cells are filled with colourless, septate branched mycelium. The hyphae soon reach the sweet mucilage surrounding the seeds when they develop with great luxuriance and finally destroy the seeds to which they gain access, generally by means of the micropyle. When the diseased patch on the rind is about the size of a penny piece, small circular

* The rusty colour of the pods attacked by "thrips" is caused by the formation of a cork layer, below the epidermis, which cuts of all the cells above it. These cut off cells consequently dry up and turn brown. The cork layer is really a new epidermis layer formed on account of the numerous perforations made in the original epidermal cells by the "thrips."

mounds, about the size of a pin's head, can be seen about the centre of the brown area, on the rind from which a greyish white powdery dust is expelled which turns black in a short time. This dust is composed of elliptical dark brown one-septate spores measuring on the average 20 by 10 microns. The small mounds into which the surface of the pod is raised are found to be due to the pycnidial fructifications of a fungus in which the above spores are formed which rupture the epidermis and liberate the spores through a small circular opening or ostiole at the apex of the pycnidium.

Steps were next taken to grow this fungus artificially, and no difficulty was experienced in obtaining hanging-drop cultures, containing a single spore, by the well-known methods. (5) The spores germinate in about two hours, (temperature 28-30 C°) in sugar-cane extract stiffened with 15 per cent. gelatine and acidified by the addition of ·1 per cent. tartaric acid, by sending out a long colourless hypha which branches copiously and becomes septate after a time (24 hours after sowing) when fusion of the hyphae is common. When seven days old, the mycelium is olive-green in colour and many of the darker segments contain oil drops and have thickened walls after which resting conditions no further development was noted in hanging drops, except a dark brown resinous covering on the hyphae like that mentioned by Bauke. (1)

In plate cultures a copious development of white mycelium was obtained at first, and in three days dark bodies were noted on the surface of the plates which rapidly developed and in six days proved to be pycnidia containing spores identical with those from which the cultures were formed.

Next the fungus was grown on sterile cacao and oak wood infected with mycelium from single spore hanging drops. A whitish grey mycelium developed, and dark bodies made their appearance nine days after infection, which proved, when eighteen days old, to be pycnidia containing the spores of the fungus. No other spore formation was noted in the various cultures made.

Infection Experiments.

These were carried out at the Botanic Station, Grenada, during February and March 1901, by means of pure cultures of the fungus obtained as described above. They were as follows:—

1. On February 24, I placed some of the actively growing mycelium of the fungus, together with some of the food material, in a small cavity made in the rind of a nearly ripe healthy cacao pod, taking precautions to sterilise the needles used and to wash the outside of the pod, where the incision was made, with an alcoholic solution of corrosive sublimate to destroy any chance spores that might be thereon. Afterwards the wound was bound up with a water-tight bandage. Another similar pod near by was treated in a similar manner except that no mycelium was placed in the cavity. This served as a control. The result of this preliminary experiment was most marked. On March 1, that is to say, five days afterwards, about a

quarter of the surface of the infected pod had turned brown and on March 4 the whole pod and its contents were decayed and there was a copious development of pycnidia containing spores, all round the point of infection, which agreed exactly with those from which the artificial cultures had been made. The control pod showed no signs of infection.

2. On March 11, the above experiment was repeated, and, in this case, two nearly ripe pods were infected with mycelium from a pure cultivation, while a third was used as a control. On the March 14 three days afterwards- the two pods into which the fungus had been introduced showed very distinct infection while the control experiment gave negative results.

3. On March 4, infection experiments were made on four cacao pods which were green and only about half-grown, in order to determine whether the spread of the fungus is as rapid here as in nearly ripe pods. Proceeding as above, it was found that infection with spores was apparent in a week and that infection with artificially grown mycelium or with the diseased tissue from other affected pods was much more rapid in the same time. The two control pods showed no infection. On the whole there did not appear very much difference in the rate at which the disease spreads in ripe and unripe pods. In both it is extremely rapid.

4. In all the above infection experiments the rind was previously wounded as, time being short, rapid results were necessary. A preliminary experiment, however, was made in order to find out if the spores were able to infect a pod directly. On March 4 a drop of sterile water containing many of the spores of the fungus was placed on a ripe cacao pod and the drop was covered with a small glass cell which was sealed on to the pod by means of budding-wax. The cell was-then covered with a bandage to shield the spores from direct sunlight. On March 11, it was found that the spores had germinated, but no penetration of the rind by the mycelium was noted. Unfortunately it was not possible then to initiate a series of experiments on a large scale to settle this point definitely, but I hope to carry these out at an early date and also to spray the pods of several trees with spore-infected water.

Natural Infection.

Observation of a large number of cacao pods attacked by this disease discloses the fact that the disease generally makes its appearance either at the groove round the insertion of the pod stalk, the free end of the pod, or at the point of contact between a pod and a branch. These places are those where rain-water is likely to remain for the longest time, and where spores have the best chance of germinating and infecting the pod directly. These observations and the fact that the disease is most prevalent near the "breaking grounds," where the fungus lives saprophytically and produces myriads of spores on the numerous old husks lying on the ground, as well as the absence of insect attack on the diseased pods, point strongly to the idea that infection is brought about by spores without the necessity of a previous wound. This matter of course, can only be placed

beyond doubt by a further series of experiments as indicated above.

Distribution of the Fungus.

Besides living on old cacao husks and on living pods, the fungus was commonly found on dead cacao trees, old prunings, and also on diseased sugar-cane in places where this cultivation is carried on among the young cacao. As will be shown below in the case of the cacao tree itself, the fungus can behave as a parasite, and in the case of the sugar-cane, an investigation on the subject which has just been completed and which it is hoped will be published shortly, demonstrates the fact that the fungus is also parasitic on the cane. These facts are of importance when discussing prophylactic measures, and are dealt with below.

Systematic Position.

In the absence of higher fructifications than the pycnidia found, the fungus must be referred to the *Fungi Imperfecti*, and on account of the nature of the pycnidium and the brown two-celled spores it falls into the sub-division *Sphaerioidaceae-Phaeodidymeae* of the *Sphaeropsideae* (23) which comprises the genus *Diplodia* and several of its allies. In many respects the fungus appeared to belong to Fries' genus *Diplodia*, and to confirm this diagnosis, specimens were sent to Kew where the fungus was determined by Mr. Massee as *Diplodia cacaoicola* P. Henn., and a note was attached to the effect that the species was first described by Hennings (8) as occurring on dead cacao branches in the Cameroons, but no mention was made of the parasitic nature of this form. A fungus closely allied to this, viz., *Botryodiplodia Theobromae* Pat., is mentioned by Engler and Prantl (23) as occuring on cacao fruits in Ecuador. Lecomte and Chalot in their book on cacao (11), in discussing the South American diseases known as *Mancha* (3,4) state that Patouillard found this fungus in diseased cacao pods from Ecuador and that probably the pod disease in which the rind turns brown and the whole fruit dries up and which is one of the forms of *Mancha*, may be due to this fungus.

A form probably identical with *D. cacaoicola* has been noted attacking sugar-cane in Porto Rico, and specimens were sent to Kew in 1878 for examination and the following note on the subject is taken from the *Kew Bulletin* (7):–

"These specimens were submitted to the Rev. M. J. Berkeley who gave the name of *Darluca melaspora* to the fungus present on the canes. The fungus was afterwards very briefly discribed under Berkeley's name by Mr. Cooke in *Nuovo Giornale Bot.*, vol. 10, p. 26 (1878) who incorrectly gave the locality as Australia instead of Porto Rico. Saccardo has added to the confusion by changing the name to *Coniothyrium melasporum* in quoting Cooke's diagnosis incorrectly in *Syll. Fung.* vol. iii, No. 1799. Finally Prillieux and Delacroix in their paper on sugar-cane diseases (*Bull. Soc. Mycol. de France* tom. xi., p. 75, 1895) have fallen into the error of considering the melanconium stage of *Trichosphaeria Sacchari*, Massee, to be synonymous with *Coniothyrium melasporum* (Berk.) Sacc. Examination of

Berkeley's type specimen shows that the fungus is a *Diplodia*."

Remedial Measures.

It is obvious when we consider the character of this disease that no steps can be taken, with any hope of success, to arrest the spread of the fungus when once it has gained access to a pod—in other words, there is no "cure" for the disease. Preventive measures alone are possible, and those must be directed towards the destruction of everything in the plantations which harbours the fungus, with a view of preventing further infection by means of spores. The following treatment is suggested for dealing with the disease:

1. As a general rule care should be taken not to allow the pods to get too ripe, as the fungus seems most liable to attack pods in this condition. Again, ripe pods, showing small brown discoloured areas, should be picked at once so as to save the beans if possible.

2. All husks or shells left after the beans have been extracted, should be buried as soon as possible under the trees, and, if the buried heaps are large, lime should be added to hasten decay and prevent local souring of the soil. There are two obvious reasons why this expense in burying pods should be incurred. First, there is the advantage to the soil in supplying humus, and secondly, the fungus is deprived of a substratum on which it thrives and produces countless millions of spores which may infect living pods. The "breaking-grounds" should be moved from time to time so as to give as many trees as possible the benefit of this manuring. Recently, while making a tour through the island of Grenada, I was very forcibly impressed by the general absence of this disease in plantations where the pods were systematically buried, and also by its presence on estates and small holdings where this practice had not yet been adopted. Indications are not wanting, however that cacao planters are realising the importance of this step, both from the point of view of the enrichment of the soil and the prevention of disease.

3. All badly diseased pods on the trees where the fungus has reached the beans, and all old husks on the ground which have turned black and become covered with the sooty spores of the fungus, should either be buried away from the cacao trees or else burnt.

4. All dead cacao trees, old prunings and branches should be periodically collected and burnt, and the ashes, which are rich in potash, spread under the trees. This proceeding is necessary because the fungus lives on dead cacao wood and will thus be able to infect healthy pods.

TRINIDAD CACAO POD DISEASES.

Two other pod diseases have been noted in Trinidad by Mr. J. H. Hart and, as far as the West Indies are concerned, seem to be almost confined to that Colony. These forms were examined at Kew from material sent from Trinidad, and they are described and figured in the *Kew Bulletin* (17). Mr. Hart

has reproduced the original descriptions of these fungi in his writings on the subject (18, 19, 20, 24, 31).

Reference is made to a cacao pod disease in Ceylon by Mr. J. B. Carruthers (13, 14, 15) which is ascribed to a member of the *Peronosporeae*, and which would seem to be closely related to, if not identical with, *Phytophthora omnivora*. Carruthers' observations were made in Ceylon in 1898 and he appears to have first drawn attention to this disease. His report (15), however, does not contain conclusive evidence as to whether the pod disease in Ceylon is caused by one of the *Peronosporeae* or by a *Nectria*, or by both.

The more important of these Trinidad pod diseases is due to the fungus *Phytophthora omnivora*, DeBary, a form which attacks various seedlings in Europe. The other disease is due to a new fungus, *Nectria Bainii*, Massee, which appears to be rare.

Phytophthora omnivora, De Bary.

The life-history of this form is well known, having been worked out by Hartig. Two classes of reproductive organs are common in the group to which this fungus belongs, and they serve definite purposes. One class of spore (conidia) serve to spread the fungus rapidly during the period when conditions favour its development; and the other (oospores) are resting spores which are formed by a sexual process in the tissues of the plant attacked and enable the fungus to tide over an unfavourable period like a drought in the tropics. The appearance* of the reproductive stages of this fungus in the case of the cacao pod are described in the *Kew Bulletin* (17) as follows :—

"The conidial form of fruit appears as a very delicate white mould on the surface of the part attacked. The conidia or reproductive bodies are ovate or egg-shaped, being attached at the broad end to a very slender stalk, which shrivels and liberates the conidium when mature. This condition of the fungus flourishes for a few weeks during the period of active growth of the host plant ; and as the conidia are produced in immense numbers and in quick succession and are dispersed by wind, insects, or rain, being washed from diseased parts of a tree to healthy parts, it can readily be understood why the pest spreads so quickly when once established. Conidia that happen to alight on young pods germinate at once, penetrate the tissues, and quickly produce a new centre of disease which furnishes more conidia in due time.

"During the period occupied in the production of the external form of fruit described above, the mycelium of the fungus spreads rapidly in the substance of the pod and gives origin to a second form of fruit imbedded in the tissues of the pod. The reproductive bodies, known as resting spores (oospores), remain for some months in a passive condition and

* A plate containing illustrations of the two fungi causing pod diseases in Trinidad was given with Mr. J. H. Hart's paper on "Some Fungi of the Cacao tree," in the *West Indian Bulletin*, Vol. 1. pp. 422—7. [Ed. W.I.B.]

are eventually liberated by the decay of the pod, when they germinate, the bodies produced on germination being conveyed by wind to the young pods, germinate in their turn, enter the tissue, and in a few days time produce the conidial form of the fungus on the surface of the pod."

Remedial Measures.

In suggesting remedial measures to check the spread of this fungus we must bear in mind (1) the fact that the spores which ordinarily spread the disease—the conidia, —are formed *outside* the pod; (2) that the resting or resistant spores of the fungus —the oospores -are formed *inside* the tissues of the diseased pods; and (3) that any tendency towards excessive humidity under the cacao trees is a powerful factor in favouring the spread of the disease. Consequently the following measures would appear to meet the case:

1. Reduction of shade. Where cacao is grown under shade, as in Trinidad, and where this disease is prevalent it would be advisable to diminish the number of the shade trees and to prune the cacao trees as much as possible so as to considerably reduce the humidity of the atmosphere.* In this way conditions could be adjusted so as to be unfavourable to the development and spread of the fungus while not interfering with the growth of the cacao tree.

2. Destruction of diseased pods. As in the "brown rot" disease above, the greatest care should be taken to bury all pods or husks, and to collect and burn all the diseased pods found on the trees.

3. In badly diseased spots and where the above measures have proved inadequate, spraying the unattacked pods with "Bordeaux" mixture†, should be undertaken as a further preventive measure. This solution should be applied with a knapsack sprayer ‡ at intervals of ten days, and at least three applications should be made. It will, of course, be unnecessary to spray the whole of the trees on an estate; it will probably be sufficient to treat those trees at the points where the disease has made its appearance.

Nectria Bainii. Massee.

This form, which appears to be rare in Trinidad and has apparently not yet been detected in any other island in the West Indies, is described in the *Kew Bulletin* (17) (where a technical diagnosis by Mr. Massee is also to be found) as follows:—

"This parasite causes semicircular dark blotches to appear on the pods, the diseased portion becoming soft and watery. At a later stage the blotches become covered with a loosely

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* Sudden reduction of shade is often injurious, and this remedy, if adopted, should be applied gradually. [Ed. W.I.B.]

† Details as to the preparation, application and cost of "Bordeaux" mixture will be found in an Appendix to this paper.

‡ A suitable form of knapsack spraying machine is the "Success" knapsack sprayer described and figured on p. 188 of this number. [Ed. W.I.B.]

interwoven layer of yellowish rust-coloured or orange mycelium which is studded over with the minute bright red perithecia or fruiting organs of the fungus.

"The perithecia are often preceded by a small snow-white *Fusarium*-like mould, which from analogy with other species may be a conidial condition of the *Nectria*. But the connection has not, however, been proved by cultures.

"This parasite may possibly be quite rare; but great care should be taken to arrest any attempt on the part of the fungus to attack the trunk of the cacao tree, for as already stated the destructive canker disease of the cacao in Ceylon is caused by a *Nectria*."

This fungus can hardly be said to be of great economic importance at present, and further study of its life-history and distribution is needed. It is extremely probable that it could easily be kept in check if the simple precaution of burying all old "husks" or "shells" of the cacao pods were adopted as part of the estate routine, and if attention were directed to the prompt destruction, by burning, of all diseased pods found on the trees.

STEM DISEASES.

Of far greater importance than the pod diseases described above are those stem diseases which injuriously affect and frequently kill the cacao tree itself. Up to the present two distinct stem diseases have made their appearance in the British West Indies; while a third has, so far, only been found in Surinam where it has done considerable damage.

"CANKER" DISEASE OF THE STEM.

The stem disease known as cacao "canker" appears to have come into prominence, for the first time, in Ceylon in the early part of 1897 where, however, it had been noticed in 1892 and perhaps even earlier. The main character of the disease, as well as certain remedial measures, were dealt with by Mr. J. C. Willis (10) who ascribed the disease to a fungus. Willis lays stress on the fact that the disease is practically confined to the "old red" cacao of Ceylon (Criollo), while the Forastero is usually unaffected. Later, Mr. J. B. Carruthers was appointed by the Planters' Association of Ceylon to investigate the disease, and his work is summed up in three reports which appear in the *Tropical Agriculturist* (13, 14, 15) This investigator showed that the disease was caused by a parasitic fungus which he identified as *Nectria ditissima* Tul. (22). His results proving, by artificial cultivation, a genetic connection between the conidial forms and the perithecial fructifications of the *Nectria* found on the diseased trees. An account of controlled infection experiments made with pure cultivations of the fungus and with the ascospores themselves has apparently not yet been published. In his reports which have already appeared (13, 14, 15) and which deal largely with remedial measures, Mr. Carruthers refers to the difficulty he

experienced of growing the fungus artificially on account of bacteria and fungi. One point noticed by this investigator in Ceylon (14) is of special interest to the West Indian cacao planter the fact that the *Nectria* of the cacao canker also attacks the shade tree *Erythrina umbrosa*. No observations on this important point seem to have been recorded in the West Indies.

The "canker" disease was first noticed in the West Indies by Mr. J. H. Hart who sent specimens to Kew for identification towards the end of 1899. Mr. Massee's report on this material is dated November 2 of that year and appears in the *Trinidad Bulletin* (29, 31), and elsewhere (27). There are several references in *Der Tropenpflanzer* (21, 25) and in the *Revue des Cultures Coloniales* (26) to the Ceylon investigations and to the occurrence of a canker disease in Trinidad.

While investigating the diseases of cacao in Grenada in February and March of the present year, the writer (32) found that a "canker" disease of cacao trees was fairly common all over the island, and exhibited characters closely resembling those of the Ceylon disease. Later (April 1901) the disease was noticed in Dominica, where it appears to be common.

The first well-defined symptom of this disease is a reddish gummy liquid which oozes out of the bark of the stem and when dry gives a rusty appearance to the bark. This may be termed the "bleeding" stage and even now the disease is well established. On cutting into the tree at these points it is found that the bark is deep claret red in colour, and moist and soapy to the feel. The discolouration extends to the young wood and on removing all the diseased bark it can be seen that the darkening of the wood extends for some distance under the still healthy bark, and that the diseased patch increases in size from beneath outwards rather than from the surface. The disease may start from any point of the stem, and in many cases there are two or three points of attack on the same tree. The spread of the diseased area varies a good deal. Sometimes when the patch is only three or four inches in diameter it rapidly extends on either side and "rings" the tree. When this is complete the tree dies off rather suddenly, often bearing a full complement of leaves and pods in all stages of growth. In other cases the diseased area extends slowly in all directions and "ringing" does not take place for some time. In such cases the death of the tree is much more gradual than before, the branches immediately above the diseased patch dying off first of all, followed by the rest as the diseased patch extends. In some cases, and these are apparently rare, the tree recovers from an attack by cutting off the diseased area by the growth of a callus underneath. In these cases, however, the disease had not reached the wood. In general, diseased trees rarely occurred singly, but several were noted close together indicating that the disease had spread from one tree to several of its neighbours.

Nature of the Disease.

Microscopic examination of the discoloured bark and wood of trees attacked by this disease shows that the tissues are

penetrated in all directions by the mycelium of a fungus, and that there is a more or less definite cork cambium surrounding the area of diseased tissue. Two distinct fungi occur on the diseased areas : sometimes alone, on other occasions together. In the earlier stages of the disease white pustules make their appearance in the cracks of the diseased bark which prove to be a mass of parenchymatous hyphae bearing numerous unicellular conidia and *Fusarium*-like multi-cellular conidia on short conidiophores. Later on colonies of perithecia make their appearance, which are either yellow or red in colour. The red perithecia contain asci containing one-septate spores and have the characters of the genus *Nectria*. The yellow perithecia contain three-septate spores and evidently belong to the genus *Calonectria*. Specimens of these red and yellow perithecia were referred to Kew for identification, and Mr. Massee regards them as new species, *Nectria Theobromae* and *Calonectria flavida* respectively. Although it is highly probable that the conidial stages referred to above and the ascigerous conditions belong to the two abovenamed fungi, nevertheless the matter requires proof; and investigations on this subject are in progress by the writer.

Preliminary infection experiments made by introducing ripe ascospores into wounds in the cacao tree were made in Grenada in March in the case of both these fungi, and in each case distinct infection was produced, thus indicating their parasitic nature. The matter, however, needs much further investigation. In Dominica, *Calonectria flavida* alone was found in trees attacked by canker, and in each case it was noted that the yellow perithecia apparently follow the conidial stages. Since there was only one fungus present here, accurate measurements were made of the various spores. The unicellular, elliptical conidia measure from 6·6 to 11 microns by 4·4 microns. The five to seven-septate *Fusarium* conidia measure from 50 to 80 microns by 4·5 to 8·5 microns and the three-septate ascospores measure 22 × 9 microns. Mr. Hart has noted this fungus in Trinidad (July 1901) where it appears to have done some damage. In Dominica trees attacked by this fungus showed in April last an extraordinary development of flowers and buds, and it appears that this is another characteristic of the disease as the malady is known locally as the "flowering disease."

In Grenada trees killed by "canker" are supposed by the small holders to have died on account of their tap-roots having struck a flat stone or a somewhat impervious stratum, locally known as "tiff." I was unable to find anyone who had verified these alleged causes by actual excavation, and in the case where a tree attacked by the canker disease was dug up for my benefit, nothing of the kind was found and the root system was quite healthy. Several trees suffering from this disease were found to be attacked by white ants. On careful examination, however, it was found that in each case the ants were followers of the fungus disease and did not attack the healthy wood. A similar state of things was observed in Ceylon by Messrs. Willis and Green (10), where the diseased bark was frequently attacked by a boring beetle (*Tomicus*.)

Remedial Measures.

Until the life histories of the fungi concerned in the "canker" disease of cacao have been thoroughly worked out, as well as the means by which healthy trees are infected are clearly demonstrated, remedial measures can only be put forward tentatively, and from this point of view it is proposed to treat the subject in the present paper.

1. Treatment of wounds made in pruning and removing beetle grubs. Since the group of fungi to which the forms found on the diseased trees belong are wound parasites, it is advisable to cover all wounds with a coating of tar to prevent the infection of the tree by means of spores. As far as practicable the cuts should slope in such a way that rain water runs off easily and the surface dries quickly. Tarring will only be satisfactory if the pruning is done at a time when the sap is not rising, as in the dry season, and if the least possible quantity of tar is used. There are several other obvious advantages to the cacao tree in tarring wounds besides the prevention of "canker." Local wood rot is prevented and the tree covers the wounds with the least expenditure of material by the growth of a callus, and also borers like the cacao beetle (*Steirastoma depressa*) are prevented from laying their eggs on the freshly cut surfaces. Neglect of this precaution in the past is obvious in many of the small holdings in Grenada where so great has been the damage done by insects and fungi that the trees have been never able to cover their wounds by fresh growth and their efforts in this direction have so told upon their vitality that their bearing powers have been very considerably reduced. On the other hand, in several of the larger estates where "tarring" has been adopted for some time and where very extensive pruning has been done, the trees are bearing well and appear remarkably healthy.

2. All dead trees killed by the "canker" disease should be cut down *at the ground* and burnt, along with all the dead wood found in the cacao plantations. This is necessary, since the canker fungi are frequently found on dead cacao branches lying under the trees and on old stumps.

3. The diseased bark of the "bleeding" patches should be cut out as soon as noticed. Since the mycelium of the fungus is often found in the apparently healthy bark surrounding the diseased tissue, it is necessary to cut out the claret coloured bark and about an inch of the surrounding apparently healthy bark as well. When the disease has reached the young wood, care should be taken to cut out any discoloured wood that may be noted. The wounds should be tarred over, and the diseased bark carefully collected in a sack or tin and burnt. The cutlasses or knives used in this work should not be used for pruning other cacao trees until they have been thoroughly washed and cleaned. In order to enlist the assistance of the estate workmen in this treatment a small reward might be given for every tree discovered to be suffering from this disease. Mr. Carruthers has recommended (14, 15, 22) shaving the bark with a knife, with a view of drying up the mycelium, but the treatment does not seem to have been a great success and can hardly be recommended.

4. In cases where the disease is established to such an extent that cutting out the diseased bark would not be likely to save the tree, it should be cut down at some distance below the diseased area and replaced, if possible, by a sucker. When, however, the disease is on a level with the ground this is often impossible and the best way is to remove the tree at once and replace it by a fresh one. All trees cut down in this way should be burnt immediately. Mr. Carruthers (14) states that suckers are not so liable to the disease as ordinary stems, and this would be an additional argument for the replacement of diseased trees thereby.

Diplodia cacaoicola. P. Henn.

During the progress of the investigation of the fungoid diseases of cacao in Grenada (32) it appeared highly probable that some damage was being done by this fungus to the cacao trees, both old and young. It is quite common in Grenada to see cacao trees dying back to a slight extent at the extremities of the highest branches, a phenomenon which is probably due either to drought, diminished root action, poverty of soil, wind, sun, or perhaps to a combination of these causes. In such cases there is a sharp line of demarcation between the dead and living tissue, and although fungi are to be found in the dead wood they are only saprophytic.

In other cases, however, it was found that this dying back was going on to an alarming extent, frequently extending to the larger branches and even to the trunk of the tree itself. In such cases there was no line of demarcation between dead and living tissue; but an intermediate zone often two feet in length, always occurred between the distinctly dead and living branch. I have noted a similar state of things in St. Vincent.

The prevailing idea in Grenada as to the cause of this disease was that "thrips" were responsible for the damage. As already stated by Mr. Lefroy, in the previous article, a certain limited amount of injury to leaves could be put down to this pest in some localities, nevertheless the number of these insects present was not sufficient to cause any appreciable damage. Examination of the diseased branches showed that a fungus was rapidly making its way down the wood and afterwards attacking the surrounding bark. At a short distance, three or four inches, behind the advancing mycelium, pycnidia were discovered breaking through the bark which contained sooty brown bicellular spores which agreed in all their characters with the fungus causing the "brown-rot" disease of the pods—*Diplodia cacaoicola.* The manner in which the mycelium spreads in the wood is of some interest. Very thin sections showed that the hyphae passed from element to element by means of the numerous pits in the walls—the entering tip of the hypha constricting itself to pass through the pit and expanding at once to the normal size after the passage. It now became necessary to find out, by infection experiments made on healthy cacao trees with pure cultivations of this fungus, whether or not this form is parasitic. To this end the following

experiments were made at the Grenada Botanic Station:-

1. On February 24, two branches about two inches in diameter were selected for the experiment. The outer dry bark was carefully peeled off about one square inch of the surface which was then sterilised with alcoholic corrosive sublimate. A small chamber was then made with a sterile knife at these points by raising the bark and cutting out the tissues underneath down to the wood. Into one of these a portion of a pure cultivation of the fungus was introduced, and the whole covered with a water-tight bandage. The second branch was treated in exactly the same way except that no fungus was introduced. This served as a control experiment. On March 4,- eight days afterwards- it was found (in the case of the branch where mycelium had been introduced) that the bark had been killed to a distance of eight inches above and below the point of infection, and the branch was nearly ringed. The spread of the mycelium was much more considerable in the wood and could be traced about a foot above and below the point of infection and to a considerable depth in the wood. Numerous pycnidia of the fungus were developed under the attacked bark. The control experiment showed no infection.

2. Eight healthy cacao plants, about eight months old, growing in bamboo pots were next experimented upon. On March 4, numbers 1 and 2 were infected with the spores of the fungus taken from a pod attacked by "brown-rot" by introducing them into a slit made in the bark of the stem. Numbers 3 and 4 were similiarly infected with small portions of the diseased rind of a cacao pod attacked by "brown-rot" which contained active mycelium of the fungus. Numbers 5 and 6 were infected with mycelium from a pure culture, and numbers 7 and 8 were control plants. After infection the wounds were bound up with a water-tight bandage, and the plants were placed in the shade and watered daily. On March 12, the fungus had established itself to a greater or less extent in all the plants from 1 to 6, while numbers 1 and 6 themselves had been killed thereby. The control plants showed no infection.

3. Four extremely vigorous young cacao trees about eighteen months old, which had been planted out at the usual time, were selected for this experiment. On March 4, three were infected under the bark with spores, diseased rind from a cacao pod attacked by the fungus, and pure culture mycelium respectively. The fourth tree was used as a control experiment. By March 12 the fungus had established itself in the first three trees, and especially in numbers 2 and 3 which had been infected by means of a small portion of the tissue of a diseased pod and by artificially grown mycelium respectively. Here the fungus could be traced in the young tree to about eight inches above and below the point of infection, and the characteristic pycnidia of the fungus had developed in the bark near this point.

4. An experiment was now performed in order to determine whether infection could be obtained by spores without first of all piercing the bark. A drop of water containing

the spores of the fungus under discussion was placed on a branch of an adult cacao tree and covered with a small glass cell which was sealed to the bark with budding wax and shielded from the sun. After seven days it was found that, although the spores had germinated, no penetration of the bark by hyphæ could be detected. Time did not permit of further experiments on this point. The above experiments, however, show conclusively that the fungus can labour as a wound parasite, and observations in many cacao plantations showed clearly that with trees in a certain condition of ill-health, the fungus was capable of pronounced parasitism. It appeared that when trees were weakened by various causes and when dying back was rather pronounced this fungus was capable of attacking the trees to such an extent that it was able to change the state of ill-health of the tree into a pronounced condition of disease. The destruction of the upper branches of the tree would materially reduce the available assimilating leaf surface and thus weaken the tree, while the inroads of the fungus would be more and more rapid.

Remedial Measures.

The main facts already ascertained with respect to this fungus point to its being a wound parasite and capable of doing extensive damage to sickly trees. This would suggest the following remedial measures:—

1. The improvement in the health of the cacao trees when dying back is noticed. Something might be done by shelter belts, judicious manuring, forking and drainage, to increase the vigour of such trees, but the individual planter's judgement will be the soundest guide in this matter.

I do not think this fungus would be very destructive to well-tended vigorous trees, so that the planter, should do all in his power to improve the condition of unhealthy trees.

2. Wounds made in pruning and removing beetle grubs should be tarred as suggested above.

3. All diseased cacao pods and dead cacao wood found in the plantations should be burnt. Old husks or shells should be buried.

4. In cases where trees are being killed by this fungus they should be replaced by a sucker whenever possible. Perhaps heavy pruning in the case of trees, where dying-back is excessive, might check the disease and enable the tree to recover.

WITCH-BROOM DISEASE OF SURINAM.

(*Exoascus Theobromae.* Ritz. Bos.)

A curious disease of cacao has lately made its appearance in Surinam which causes "witch brooms" (Hexenbesen) to be produced in the branches of the trees attacked. These are composed of a bunch of greatly enlarged gouty twigs which show a decided tendency to grow in a vertical direction. The disease seems to have been noted for the first time in 1898 when specimens were forwarded to Professor Ritzema Bos of Amsterdam who discovered asci of the *Exoascus* type on the

underside of two rudimentary leaves (34). From this and the anatomical features of the affected twigs he concluded that the disease was due to a new fungus which he named *Exoascus Theobromae.*

Specimens of diseased twigs have been forwarded to the Department by Mr. J. H. Hart and have been examined. None of the characteristic fruits of *Exoascus Theobromae* were detected on them, but on the enlarged twigs longitudinal whitish pustules, about one-eighth of an inch in length, were found bursting through the bark. Examination of these showed that they were made up of a cushion of fungus parenchyma on which numerous five to seven septate crescent-shaped conidia of the *Fusarium* type, measuring from 56 to 60 microns in length and 4·5 microns in breadth at the widest part, were borne on short conidiophores. The material had been treated with formalin before being sealed up in the kerosene tin in which it arrived, so that it is unlikely that this fungus developed after the material was collected. It is probably the *Fusarium* stage of some *Nectria*, and may have some connection with the disease. The matter could only be cleared up by an investigation on the spot. Specimens have been examined by Mr. Massee (33) who also failed to find the characteristic fruiting organs described by Bos.

On the other hand a comparison of the microscopic structure of the diseased and healthy twigs is in complete accord with the anatomical changes occurring in "witch brooms" described by Mr. Worthington Smith. Thus in the diseased twigs in the cacao "witch brooms" there is an abnormal development of all the extra-cambial tissues as well as of the medullary rays and the pith. The elements of the wood have also thinner walls and a larger lumen than in the healthy branches.

The bearing powers of the trees in Surinam attacked by the disease are extremely small, and therefore the disease becomes of economic importance. At present the fungoid diseases attacking cacao in the West Indies are by no means few in number, and it is important that great care should be taken to prevent the introduction of this Surinam disease into the English Colonies. The Curators and Agricultural Instructors in the various islands should therefore be careful not to import cacao seeds or plants from Surinam, and also to warn planters who contemplate doing so of the great danger of such a proceeding.

ROOT DISEASE.

In several instances in Grenada circular patches of cacao trees were met with which had died from no apparent cause. They had been growing in good well-drained soil and were surrounded by healthy vigorous trees in good bearing. No indications of disease were found in the stems or branches of these trees, but on examining the root system it was found that the roots were decayed and abundant mycelium was present especially between the wood and the bast, where it was evi-

dent to the naked eye as a matted white sheet surrounding the wood. No rhizomorphs or fructifications were found, even on trees which had evidently been dead for some time, but the mycelium exhibited the clamp connections of Hoffmann (1) characteristic of the *Basidiomycetes*. A similar if not identical fungus attacks the roots of nutmeg trees in Grenada and in all probability many fruit trees in the West Indies. Thus Mr. C. A. Barber, in his report on the failure of the Dominica cacao crop in 1892-3 (6), mentions a root disease of cacao in that island which also attacks mangos, oranges, coffee and breadfruit, and which seems to be identical with the one under discussion. He also noted a similar disease in Jamaica, locally called "saltpetre" in the cacao and coffee cultivations. Last year cacao trees affected with a root disease were forwarded from Dominica to the Imperial Department of Agriculture for examination, and it was found that the root system had been attacked by a fungus, the mycelium of which exhibited characters identical with those noted in the case of the Grenada cacao root disease. Cultivations were made of this fungus in sterilised oak and cacao wood from small portions of the mycelium. A copious white mycelium developed, but no fructifications were developed although the cultures were kept under observation for six months and periodically watered with sterile water. Recently (July 1901) mango trees have been killed by a somewhat similar root fungus in Grenada, but here there was no development of white sheets of felted mycelium between the wood and the bast. A somewhat similar root disease of cacao occurs in the Cameroons (16, 30) and here again the fructifications of the fungus have not yet been found. The occurrence of the diseased trees in circular patches, and the absence of fructifications, point to the spread of the disease underground by the contact of diseased and healthy roots. It is stated in Dominica that this root disease is liable to appear in cacao fields which have been planted in recently cleared forest land and it is interesting to notice that a root disease of fruit trees (35) caused by a *Hymenomycete*, is common in Texas and other States where orchards have been planted on recently cleared forest land. Another root disease caused by *Ozonium auricomum* which is only known in the vegetative condition, and which attacks many trees in the south-western States is described by Messrs. Galloway and Woods (9).

Remedial Measures.

It has been found in the case of nutmeg trees in Grenada attacked by this disease that, unless the affected trees are isolated from the rest of the plantation by a trench, the disease spreads to the healthy trees. This method of dealing with root diseases has been for a long time successfully adopted by the foresters in Europe, and there is no reason why it should not be successful in cacao plantations. A trench about two feet deep should be dug midway between the affected trees and the surrounding healthy ones, and these latter should be kept under observation for some time in order to determine whether the isolation has been done in time. Nothing can be

done to save the trees attacked, since the root system is practically destroyed before the disease is noted. The roots of diseased trees should be carefully dug up and burnt before a new tree is planted.

SUMMARY.

It will be evident from the above that much work remains to be done to elucidate the diseases of cacao in the West Indies, and to convince the planters of the necessity of taking suitable precautions to limit the damage done by fungoid pests as much as possible. The suggestions on this subject contained in this paper may be summed up as follows :-

1. The husks of the cacao pods should be suitably buried with lime under the trees as soon as possible after the seeds have been extracted. Diseased husks should either be buried away from the cacao or else burnt.

2. All old prunings, dead trees, and dead wood in the plantations should be periodically collected and burnt. and the ashes spread under the trees.

3. Diseased trees should be replaced by suckers whenever practicable. If this is impossible the trees should be cut off level with the ground and burnt.

4. In cases of the "canker" disease the diseased bark should be properly cut out, the wound tarred and the diseased bark burnt.

5. In cases of root disease, the affected trees should be isolated from the rest of the plantation by a suitable trench. The diseased roots should be dug up and burnt before a fresh tree is planted.

6. The wounds made in pruning and in removing beetle grubs should be tarred.

7. Seeds from diseased pods should not be used for raising seedlings.

8. In cases where trees are dying back attention should be devoted to the improvement of the health of the trees by manuring, forking, draining, or the provision of shelter belts, according to the nature of the case.

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APPENDIX.

NOTE ON THE PREPARATION AND USE OF BORDEAUX MIXTURE.

Preparation: The following account of the preparation of this fungicide is taken from *Spraying for fruit diseases* Farmer's Bulletin No. 48 of the United States Department of Agriculture, by Dr. B. T. Galloway.

'The best results will be obtained from the use of what is known as the 50-gallon formula of this preparation which contains:—

Water	...	..	50 gallons
Copper sulphate	..	...	6 pounds
Unslacked lime	...	...	4 pounds

'In a barrel or other suitable vessel place 25 gallons of water. Weigh out 6 pounds of copper sulphate (blue stone), then tie the same in a piece of coarse sack and suspend it first beneath the surface of the water. By tying the bag to a stick laid across the top of the barrel no further attention will be required. In another vessel slack 4 pounds of lime, using care in order to obtain a smooth paste, free from grit and small lumps. To accomplish this it is best to place the lime in an ordinary water pail, and add only a small quantity of water at first, say a quart or a quart and a half. When the lime begins to crack and crumble and the water to disappear add another quart or more, exercising care that the lime at no time gets too dry. Toward the last, considerable water will be required, but if added carefully and slowly a perfectly smooth paste will be obtained provided the lime is of good quality. When the lime is slacked add sufficient water to the paste to bring the whole up to 25 gallons. When the copper sulphate is entirely dissolved and the lime is cool pour the lime milk and the copper sulphate solution slowly together into a barrel holding 50 gallons. The milk of lime should be thoroughly stirred before pouring. The method described ensures good mixing but to complete this work the barrel of liquid should receive a final stirring for at least three minutes, with a broad wooden paddle. It is now necessary to determine whether the mixture is perfect, and to accomplish this insert the blade of a clean penknife in the mixture for one minute. If the polished surface of the steel assumes the colour of copper plate, the mixture is unsafe and more lime must be added. If, on the other hand, the blade of the knife remains unchanged, it is safe to conclude that the mixture is as perfect as it can be made.'

Application: To ensure success it necessary that this preparation should reach all parts of the pod in the form of a fine mist-like spray. This can be brought about by the use of a properly fitted knapsack sprayer.

Cost: The principal* item of cost is that of the copper sulphate, the wholesale price of which, in London, is about 25

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* For a general discussion of the cost of spraying on a large scale, see the Appendix to Mr. H. M-Lefroy's second report on "Thrips on cacao trees,' pp. 183—90 of this number. (Ed. W.I.B.)

shillings per cwt., the retail price being three pence per pound. The cost of 200 gallons of the solution, which should be sufficient for 300 trees, will therefore not exceed six shillings. Thus the cost per acre, when the trees are planted 12 feet apart, will be about six shillings for materials each application, or eighteen shillings for three applications.

NOTE ON THE SUGAR-CANE DISEASE OF THE WEST INDIES.†

BY SIR WILLIAM T. THISELTON-DYER, K.C.M.G., C.I.E., F.R.S.

Director, Royal Botanic Gardens, Kew.

The cultivation of the sugar-cane is still, and –notwithstanding the competition of the beet in temperate countries—is likely to remain a very important part of the tropical agriculture of the Empire. But of late years it has been hampered, as is sooner or later the fate of all cultural industries, by the ravages of disease.

The problem presented to the botanist in such a case is one of no ordinary difficulty. He has to engage in a conflict with a singularly elusive enemy, and he has to discover the conditions, often by no means obvious, in which that enemy is most open to attack. And the form in which the disease, or the fungus which produces it, finally presents itself is rarely one which admits of remedial treatment. It is necessary, therefore, to trace back the fungus through its often multiform life-history, and so to discover the stage at which its mischievous course can be most readily intercepted.

The task is difficult enough when one is face to face with the problem on the spot where it presents itself. It is still more so when the material to be studied only reaches the investigator after a long voyage, more or less decayed and infested with all the fungi that attend decay.

Nothing is more common than for a fungus which has long possessed merely a scientific interest and has been preserved in herbaria in scanty specimens, suddenly to exhibit an overpowering fecundity and develop into a scourge.

Something like this seems to have happened in the West Indian cane-fields some ten years ago. A disease made its appearance which caused considerable immediate loss and apprehension of greater.

The disease in Barbados exists in two forms which, though apparently distinct, there is reason to think have a common cause. These are called respectively the 'rind disease' and the 'root disease.'

† *Annals of Botany*, Vol. XIV. No. LVI. December, 1900, pp. 609 16.

Rind Disease.

The following account is condensed from the *Kew Bulletin*, 1895, p. 81: Canes infected with the rind fungus are first noticed by dark red or brown marks in one or two joints towards the middle or base of the cane. This red patch having made its appearance, rapidly spreads upwards and downwards; the infected area darkens in appearance, and is evidently rotten. Little black specks make their appearance on the cane between the joints, breaking from the inside to the surface; finally the cane shrivels and dries up.

The bursting through of the epidermis is followed by the emission of a black filament, sometimes an inch and a half long or even more. The resulting appearance of the cane is figured by Massee (*Ann. of Bot.*, vol. VII, pl. 27, figs. 1 and 2) and by Prillieux and Delacroix (*Bull. Soc. Myc.*, vol. XI, pl. 10, fig. *A*.) The filaments are composed of agglutinated spores (*Melanconium*-stylospores) which are discharged from a conceptacle or pycnidium buried in the tissues of the internode. This phase of the fungus was first described by Cooke (*Grevillea*, vol. XIX, p. 45) from a Queensland specimen as *Strumella Sacchari*.

Massee, regarding it as the conidial stage of a Sphaeriaceous fungus, named it *Trichosphaeria Sacchari* (*Ann. of Bot.*, vol. VII, p. 516). The technical diagnosis is given in the *Kew Bulletin*, 1894, p. 84. Prillieux and Delacroix (l. c., p. 80) identified it with *Coniothyrium melasporum*, Sacc., which is founded upon a specimen from Porto Rico (not Australia), named in manuscript by Berkeley *Darluca melaspora* and described by Cooke. According to Massee (*Kew Bulletin*, 1895, p. 86), Berkeley's type specimen is a *Diplodia*, and the identification of Prillieux and Delacroix therefore falls to the ground.

All analogy would lead to the conclusion that the life-history of the rind fungus comprises more than one reproductive phase. And this proves to be the case. Massee has described the formation of *macroconidia* 'in the interior of a cane, when the tissue is disorganized,' and of *microconidia* on a wounded surface exposed to the air. Both these were obtained in a flask-culture inoculated with *Melanconium*-stylospores, the microconidia being borne on conidiophores growing into the air, the macroconidia being immersed. (*Ann. of Bot.*, vol. VII, p. 518.)

Prillieux and Delacroix (l. c., pp. 81, 82) confirm Massee's descriptions of the macro-and microconidia. And generally 'à part quelques points de detail, sans grande importance pratique, ils confirment l'opinion de M. Massee' (l. c., p. 75).

They add still another reproductive stage, that of chlamydospores (l. c., p. 81). These have also been observed by Howard.*

Went has criticized Massee's results (*Ann. of Bot.*, vol. X, pp. 583-600). His paper was written in Java, where the *Trichosphaeria*, if it exists at all, is 'only to be found on dead canes' (l. c., p. 595). But as Professor Harrison points out

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* Sir W. T. Thiselton-Dyer's note, here reproduced, prefaced a paper by Mr. A. Howard on *Trichosphaeria Sacchari*. The full results of Mr. Howard's work on this subject will be given later when experiments, now in hand, have been carried to a conclusion.—[Ed. W. I. B.]

(*British Guiana Daily Chronicle*, Jan. 15, 1897), the work of the Java experts 'appeared to be done chiefly with the white and purple transparent varieties which were relatively immune to some of the diseases affecting the Bourbon,' and Went apparently had not seen the research of Prillieux and Delacroix.

Went thinks that Massee's macro- and microconidia belong to *Thielaviopsis ethaceticus*, which produces the 'pine-apple disease.' It is to be noticed that this is not, as might be supposed, a disease of pine-apples, but a disease of the sugar-cane accompanied by a pine-apple odour. He has overlooked the fact that Massee had already called attention to its probable identity with *Trichosphaeria* (*Kew Bulletin*, 1894, p. 84). Prillieux and Delacroix had done this the following year (l. c., p. 82).

Massee obtained macro- and microconidia in a flask-culture inoculated with stylospores. Went suggests: 'The most probable explanation of this would have been that these macro- and microconidia were an impurity having by chance entered into the flask' (l. c., 591). This seems a purely hypothetical supposition. The experiment has been frequently repeated at Kew with the same result. On the other hand, Went in Java and Howard in Barbados have failed to obtain macro- and microconidia from flask-cultures of stylospores. This, however, does not prove more than that tropical conditions may be unfavourable to their production by this method. Howard, on the other hand, obtained them without difficulty when he inoculated the interior of healthy canes with stylospores, and Prillieux and Delacroix appear to have been equally successful (l. c., p. 81).

It is to be observed that while the stylospores are produced on the external surface of the cane, the macroconidia are only produced in the interior. It is not easy to see how a flask-culture of the former could be accidently infected with the latter, as suggested by Went.

In any case there can be little doubt that the macro- and microconidia met with in Barbados are actually identical with *Thielaviopsis* (Went, l. c., p. 593). And as Went sought for 'other organs of reproduction' (p. 591), it may be inferred that he regarded this only as a form-genus. A comparison of the figure in Krüger's *Das Zuckerrohr*, p. 415, of the effect of *Thielaviopsis* on the interior of a sugar-cane with that given by Massee (*Ann. of Bot.*, VII, t. 28. f. 6), showing the growth of the macroconidia of *Trichosphaeria*, will leave little doubt as to their identity.

It may be remarked that Went has ignored the striking resemblance indicated by Massee (l. c., 324) between the macro- and microconidia and their mode of production in *Thielaviopsis* and in *Ceratocystis fimbriata*, Ellis and Halsted (*Journ. of Myc.*, vol. VII, pp. 1–11), which produces the 'sweet potato black rot.' It is interesting to observe that this has also a pycnidial form, and that as in *Trichosphaeria*, the stylospores are extruded in an agglutinated mass.

Ellis and Everhart have briefly described (*Journ. Inst Jam.*, vol. I, 1892, p. 159) a sugar-cane fungus under the name of *Trullula Sacchari*. This has been definitely ascertained at

Kew to be identical with *Trichosphaeria*. As the diagnosis mentions the 'crumpent' stylospores and the 'catenulate' conidia, it is evident that these authors observed the macroconidia.

According to Went (l. c., p. 595), the *Melanconium* in Java 'is only a saprophyte, and not a wound-parasite, as the form in the West Indies seems to be.' The latter conclusion is, however, abundantly established not merely by the Kew experiments but by Prillieux and Delacroix in Paris (l. c., p. 81) and Howard in Barbados.

It is to be observed that the *Melanconium*-stage of *Trichosphaeria* seems altogether unknown in Java. Its sugar-planters are much to be congratulated. Kruger, who gives (op. cit.) a very full account of all the diseases of the sugar-cane known in Java, indicates nothing in the least resembling the 'rind fungus' of the West Indies. What is quite certain is that Went's '*Melanconium (Sacchari?)*' has nothing to do with it. Fig. 81 in the Annals (l. c.) would rather suggest that it may be a stage of some Basidiomycetous fungus. The fourth section of Went's paper (l. c., pp 595-8) is wholly irrelevant, because it is clear that he has identified under the name of *Melanconium Sacchari* two perfectly distinct things. His experimental results were made with a Javanese fungus which has nothing to do with *Trichosphaeria*. His results have therefore no bearing on its life-history. He concludes by observing: 'I regret that I am not able to experiment with *Melanconium* from the West Indies, because I do not wish to introduce this fungus in the living state into Java (l. c., p. 598).

From a practical point of view the only reproductive form of *Trichosphaeria* of importance is the *Melanconium*-stage producing stylospores. These appear to be ubiquitous in the cane-fields of some of the West Indian islands. In Antigua Barber says (*Kew Bulletin*, 1894, p. 170), 'the whole atmosphere is saturated with the spores.' The other reproductive forms of the fungus appear to be of secondary, at any rate merely of scientific interest. As Massee has pointed out (*Kew Bulletin*, 1894, p. 83): 'The *Melanconium*-stage can reproduce itself continuously, without the intervention of any other form.' It is 'the conidial form destined for the rapid reproduction and dissemination of the species. . . . The disease is caused by this phase of the fungus.' The fact is in no way remarkable. In Australia rust in wheat is propagated entirely by the reproduction of uredospores: the æcidial stage is unknown. The 'leaf disease' in Ceylon was continued and the cultivation of coffee practically exterminated by the continual reproduction of the uredospores of *Hemileia*.

Root Disease.

About the same time as the 'rind disease' a second malady of the sugar-cane, the 'root disease,' also attracted attention in Barbados. The following account is taken from the *Kew Bulletin* (1895, p. 88): 'The canes appear to receive a check in their growth; the plant dwindles down, fresh basal shoots are formed to supply the place of the dying ones, but notwithstanding this it is ultimately found that growth has been arrested

and no cane formed; and if the plant be dug up the roots are nearly all dead; and those that are still living are dotted over by little red spots.'

The resemblance of the disease above described to the 'sereh' of Java has been generally noticed (*Kew Bulletin*, 1895, p. 83). Went (l. c., p. 588) says it 'looks very much like the "sereh" in Java.'

It is again to be noticed that 'it was only the Bourbon cane affected. The Caledonian Queen and Transparent are healthy and vigorous.' (*Kew Bulletin*, 1893, p. 346.)

Diseased stools of sugar-cane were sent to Kew from Barbados for examination. Massee reported that this 'demonstrates conclusively that the disease is due to a parasite fungus known as *Colletotrichum falcatum*, Went' (*Kew Bulletin*, 1893, p. 347.) Went thinks this 'extremely improbable' (l. c., p. 588). He further says that Massee 'gives no evidence for his opinion.' It apears to me, on the contrary, that the description of the Barbados fungus given by Massee exactly tallies with Went's own description. I do not see what other evidence could be required. And Went (l. c., p. 588) admits having 'received the fungus from the West Indies.' I may now quote some remarks of my own in the *Kew Bulletin* (1894, p. 176): 'It is evident that canes infected with "rind fungus" are used for propagation. It further appears that when this was the case the resulting plants are attacked by root disease. This fact points to the conclusion that the root disease and the rind disease are really due to one and the same organism, and that the *Colletotrichum* is only another phase of the polymorphic *Trichosphaeria*. This was indeed suggested by Mr. C. A. Barber, the Superintendent of Agriculture in the Leeward Islands, in a private letter, December 1, 1893, as the result of his observations. But the evidence was not deemed at the time conclusive. The possible identity of the two diseases is still a matter under investigation at Kew.' The Barbados Commission in their Report state: 'It has been finally decided at Kew that *Colletotrichum falcatum*, Went, is simply one phase in the life-history of *Trichosphaeria Sacchari*.' (*Kew Bulletin*, 1895, p. 83). This statement was based on information furnished to the Barbados Government but not published. A healthy seedling sugar-cane was inoculated with the spores of *Colletotrichum falcatum*, and at the end of twenty days developed the *Melanconium*-stage of *Trichosphaeria*. This and the result of other experiments is still open to independent confirmation. But the practical result was of considerable importance. The sugar-cane is propagated by planting 'tops. It cannot be doubted that these were often infested with the mycelium of the 'rind fungus.' Under these circumstances they failed to develop a healthy cane but, as is believed, exhibited the symptoms of 'root disease.' According to Massee's view (*Kew Bulletin*, 1894, p. 177): 'The new canes and their rootlets are attacked by the *Colletotrichum*, which, from the evidence at hand, appears to be nothing more than a condition of the *Trichosphaeria* modified by being more or less buried in the ground.'

Using this as a working theory, the advice was given to take great precautions to avoid planting 'tops' which were possibly infected by rind disease. When followed, the result was 'a marked improvement.' (*Kew Bulletin*, 1895, p. 88).

Went (l. c., p. 581) gives the disease produced by *Colletotrichum falcatum*, the name 'red smut,' apparently having regard to the red discolouration exhibited by the interior of the affected canes. But the development of a red colour, especially in the neighbourhood of the fibro-vascular bundles, is probably not characteristic of the *Colletotrichum* but may be found in any diseased cane, whatever the cause of the disease.

BUD VARIATION IN THE SUGAR-CANE.

Careful observations and exact measurements have shown that amongst animals and plants no two individuals are exactly alike. That this is so amongst human beings and domestic animals is indeed a matter of common observation, and it is by these individual differences that we are able, for example, to recognise one person from another. Amongst plants similar differences, although not so noticeable to the non-critical observer, exist nevertheless. 'In every bed of flowers or of vegetables we shall find, if we look closely, that there are countless small differences, in the size, in the mode of growth, in the shape or colour of the leaves, in the form, colour, or markings of the flowers, or in the size, form, colour or flavour of the fruit. These differences are usually small, but are yet easily seen, and in their extremes are very considerable; and they have this important quality, that they have a tendency to be reproduced, and thus by careful breeding, any particular variation or group of variations can be increased to an enormous extent apparently to any extent not incompatible with the life, growth, and reproduction of the plant or animal.' *

This tendency to variation, occurs amongst plants in a state of nature, and is very pronounced indeed in many cultivated plants. In particular is it to be noted in those plants which are grown on a large scale, and in widely separated countries, so that they are exposed to very varied conditions of soil, climate, etc.

The sugar-cane exactly fulfils these two conditions, being cultivated on a very large scale and in very distant countries. It has been cultivated for so long that its actual origin is doubtful, but the available evidence points to all the sugar-canes grown commercially, belonging to one species *Saccharum officinarum*, Linn.

* Alfred Russel Wallace, *Darwinism*, 2nd. Ed. p. 84.

In addition to the favouring factors of extensive cultivation under varied conditions, it has also had the advantage of time, so that it is not surprising to find the sugar-cane at the present day represented by countless varieties, differing widely from one another in many characters. Habit, colour, vigour, resistance to drought and disease, time of flowering, time of ripening, sugar contents, all vary to a considerable amount. The constant aim of sugar-cane cultivators in every country is, or should be, to select those varieties which possess desirable characteristics to the greatest degree.

In actual practice two methods are known and made use of to obtain new varieties of plants, namely by taking advantage of (1) Seed or seminal variation, and (2) Bud variation.

By the phrase 'seed or seminal variation' expression is given to the fact that the seedlings of a batch raised from the same parent plant will differ, both from one another, and from their parent plants in various respects. 'Some naturalists have maintained that all variations are connected with the act of sexual reproduction; but this is certainly an error; for I * have given in another work a long list of "sporting plants," as they are called by gardeners that is, of plants which have suddenly produced a single bud with a new and sometimes widely different character from that of the other buds on the same plant. These bud variations, as they may be named, can be propagated by grafts, offsets, etc., and sometimes by seed. They occur rarely under nature, but are far from rare under culture.'

Previous to the independent discovery by Messrs. Harrison and Bovell in Barbados, and Dr. Soltwedel in Java, of the formation of fertile seed by the sugar-cane, the first method of raising new varieties was impossible, or at any rate could not be knowingly practised. It is quite possible that some seedlings may have come up in fields, and by chance have got into cultivation. But no organized selection of desirable plants from amongst a batch of seedlings, as is to-day carried on, could be made. The discovery of the seed rendered this mode practicable; its value was recognized at once, and the success with which the work has been carried on may be estimated by the fact that in the West Indies, at any rate, 'seedling canes' have, in many localities, supplanted to a large extent the older varieties. In the sugar-cane Experiment Stations in Barbados alone there are now about six thousand seedlings under experimental cultivation.

The occurrence of the phenomenon of bud variation in the sugar-cane, has so far been little noticed and even at times doubted. Messrs. Jenman and Harrison, in their *Report on the Agricultural work in the Botanic Gardens, British Guiana*, for the years 1893 - 5 write: –

'We have no faith whatever in the suggestions often thrown out to select the most saccharine canes of any distinct variety for planting out, as in every stool of canes considerable differences invariably occur in the saccharine strength of the canes, due solely to differences in age and position in the stool

* Charles Darwin, *Origin of Species* 6th. Ed. p. 8.

and other influencing conditions. We do not consider that a cutting from an older or otherwise favoured richer shoot is likely to produce a new plant of superior saccharine strength, and as a matter of fact all our experience disproves this oft-recommended idea, and we know of no analogy supporting it apart from seminal generation, no instance of "bud variation" having ever occurred in our long daily acquaintance in field and laboratory with the cane.'

In 1897 Professor J. B. Harrison in his work, on *The Results of Recent Scientific Researches into the Agricultural Improvement of the Sugar-cane* (p. 11.) says:— 'Until recently this mode [bud variation] of attaining an improved variety of cane appeared to be a favourite one with the authorities at Kew. By "bud variety" is meant the production of a variety distinct from that of the parent cane by means of a shoot springing from an eye. As the search for these "bud variations" has been recommended by such high authority it is of some interest to ascertain on what grounds the assertion that "bud variation" occurs in the sugar-cane is based. Neither Mr. Jenman nor myself, during our long individual experiences with the scientific observation of the sugar-cane —experience probably as extensive as that of any other scientific observers—have ever seen anything resembling a "bud variation" in the case of the sugar-cane, and I think that we are justified in assuming that if such variation ever occurs it is only in exceedingly rare cases.'

And further (p. 16.) 'I do not consider that the improvement of the sugar-cane by means of bud sports can be considered as a practical method, or one likely to repay the enormous amount of work necessary to search through many square miles of sugar-canes in search of what, at the best, must be of extremely rare occurrence.'

Apparently therefore no cases of bud variation in the sugar-cane had been recorded from the West Indies previous to 1897. The phenomenon had, however, been observed and taken practical advantage of in other countries. In December 1890, Mr. John Horne, then Director of Forests and Botanical Gardens, Mauritius, in a letter to the Director of the Royal Gardens, Kew, published in the *Kew Bulletin* for 1891 says:—

'Raising canes from seed to get improved varieties will be a long and tedious affair, and there will be many disappointments before a really good hardy sugar-yielding variety will be obtained. I think it probable that more and better results will be obtained by good cultivation and by new varieties from bud-sports. Of these last we have eight or nine in Mauritius alone, some of them are very fine canes and they are extensively planted. Most of them are hardier than their parents and yield more sugar. They are mostly obtained from new canes recently introduced. The sudden change of climate, soil, and other circumstances cause them to be thrown off. More of them might be obtained if the planters were more observing than they are, and closely followed the cane cutters when cutting the canes. Thus they would range all their fields over, perhaps areas amounting to 1,500 acres, matching each cane

1. Bud Variation in Sugar-Cane.

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as it is seen cut. As things are, a new variety is only observed should it chance to spring up in an outside row.'

Dr. Stubbs also, in his book on the *Sugar-cane*, the preface to which is dated June 30, 1897, records (p. 66) the following experiments carried out in Louisiana: –

'As an illustration of bud variation, eight years ago some stalks of cane, partly white and partly purple, were selected from the field of Soniat Bros., Tchoupitoulas plantation. They were called by them bastard canes. These stalks were taken and planted as follows: First row, the entire stalk; second row, the white joints of each stalk; third row, the coloured joints of each stalk. At the end of the season four distinct canes, as far as colour could direct us, were obtained. Types of the four new varieties were selected and separately planted and the next year were found to be nearly pure. Selection and separate plantings have been made each year since. These canes have been named as follows: First, a white cane No. 20. Soniat, after the owners of the plantation; second, a light striped, No. 59, Nicholls, after the then Governor of our State; third, a light purple cane, No. 61, Bird, after the then Commissioner of Agriculture; fourth, a dark striped, No. 65, Garig, after the other member of the Board of Agriculture. The yield and analyses of these canes have been annually made. They, except the white, are entirely different from any other cane in our collection.

'They are now permanent canes in our collection, and with the exception of the striped varieties which have the tendency of all ribbon canes to vary under cultivation, are fairly permanent in their typical characteristic, viz., colour. Their sugar contents are fully equal to those of our home ribbon and purple canes, over which they have as yet no pronounced excellencies. They are cultivated as evidences of bud variation.'

In view of the fact that no cases of bud variation in the cane, have, apparently, as yet been brought to notice in the West Indies, it is desirable to put on record two instances which have recently come under observation.

The first case was forwarded to the Department of Agriculture by the Hon. F. J. Clarke, from Kirton plantation in Barbados, and exhibited by Dr. Morris at a meeting of the Barbados Agricultural Society in April 1899. The specimen in question was a ribbon or striped cane, the ribbon being well pronounced on the main stem. Four successive joints had thrown off shoots, the first and third of which were striped with red like the parent cane, whilst the second and fourth were unstriped, yellow canes. Four following joints therefore, on one cane, bore alternately striped and unstriped shoots. The resulting appearance was a striped parent cane bearing, on the one side two striped shoots, and on the other side two unstriped shoots.

In March of the following year, Mr. S. B. Kirton, proprietor of Arthur Seat plantation, Barbados, observed several clumps (stools) of cane showing bud variation growing in the

hedge-row of a field on his plantation. This field was examined with very interesting results.

In the case described above it will be remembered that one individual cane had given rise to side shoots, some of which were striped and some unstriped. In the Arthur Seat canes the variation had arisen earlier in the plant's growth, and the whole canes, as they sprung from the ground, were either striped or not. A single clump dug up had a most striking appearance. From a common base sprang, on one side red striped canes, and on the other side pale yellow unstriped canes.

The examination of five clumps in which the phenomenon was noticed gave the following figures :-

Clump.	White Canes.	Red Striped Canes.
A	6	6
B	9	6
C	6	1
D	5	6
E	1	10

One of the clumps was submitted to Mr. J. R. Bovell who reported : 'After careful examination I am satisfied that in this clump of canes there is a decided case of "sport" or bud variation, as the piece of cane originally planted was a bit of ribbon. From a bud of this ribbon cane there was produced a white cane which in turn produced from a bud below the surface of the ground a ribbon cane.

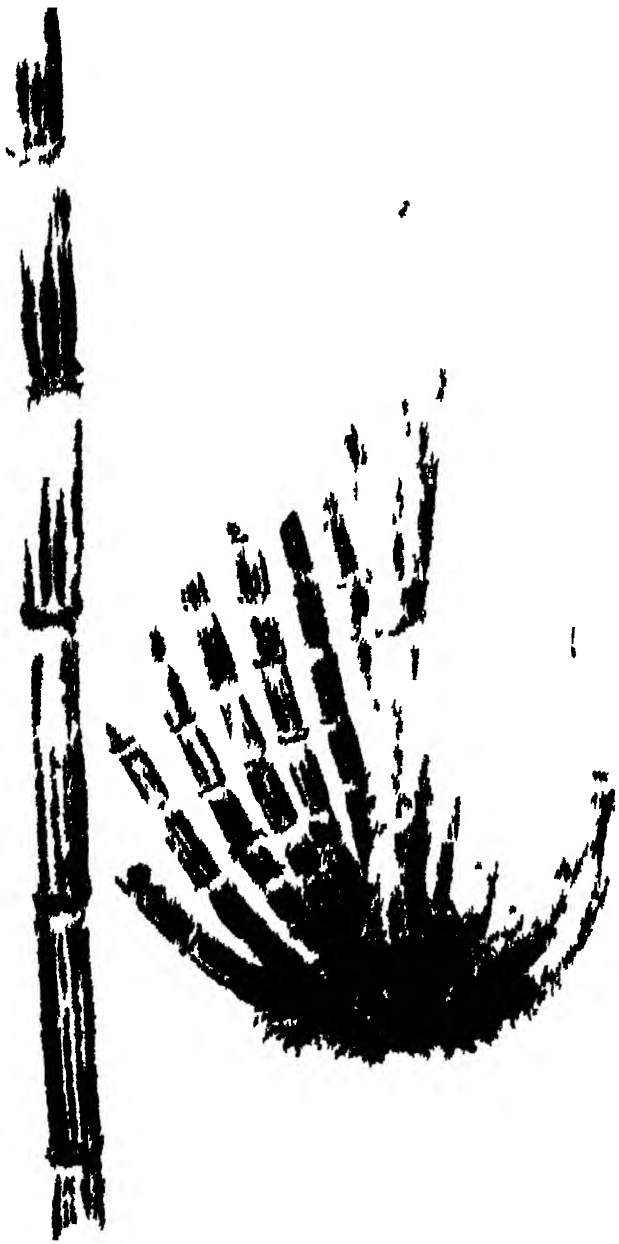
'A curious circumstance in connection with this case of bud variation, is the resemblance of the white canes to the Burke seedling cane.

'As you know, Mr. Webster, the manager of Arthur Seat when showing you the clump pronounced the canes to be "Ribbon and Burke," and certainly the resemblance is so great, that had I been shown the white canes and been asked to what variety they belonged I should have said the Burke.'

Subsequent to these observations in Barbados, Mr. James Clarke of North Queensland, in a letter to Prof. J. B. Harrison (for a copy of which we are indebted to him) records the following interesting facts :—

'Regarding bud variation, I may say that the first time I noticed this was in New South Wales where I had charge of a large sugar plantation. At that time the "gumming" disease in sugar-cane was at its height, and the cane called Striped Tanna came suddenly to the front as a hardy, healthy, disease-resisting variety.

'A few hundred-weights of this Striped Tanna cane were received and planted out on the plantation I had charge of, and when cutting those canes for plants at eleven months' growth, I noticed here and there a few thin weakly-looking stalks, quite yellow, and also some purple coloured ones without any stripes. Now, as I had planted these few cwts. of striped canes with my own hand I knew for certain there could be no mixture of varieties, and I was more convinced of this later on by finding a stalk from amongst the striped canes with the three lower joints next the ground striped like Striped Tanna and the



2 Bud Variation in Sugar Cane

upper portion of the stalk unstriped and completely yellow. On seeing this I kept all the thin yellow stalks, and also the purple ones and planted them out separately, and the resulting canes from those plants came up true to colour. I also planted the striped lower joints of the cane that was half yellow and half striped, and the cuttings from the upper yellow portion, separately, and got yellow and striped canes from the respective plants, according to colour of cuttings planted.

'When cutting Striped Singapore canes here the other day I came across what appeared to be ripe yellow Rappoe canes growing out of the middle of the Striped Singapore stools. At first I thought those stalks must have sprung from Rappoe cuttings planted amongst the Striped Singapore canes, but on closer inspection I could see at once that this was not the case, and that those yellow canes must be sports of the striped variety, for after a little further search I found stalks with purple stripes on a few of the lower joints, whilst the upper half or remaining portion of the stalk was of a uniform yellow colour.

'Again, to make sure that the yellow canes growing from the centre of the Striped Singapore stools were true sports I dug up a whole stool of mixed canes and sliced the roots through the middle, so as to expose the connections of the different stalks. It could then at once be seen that the striped canes were the parents of the yellow sports which had sprung from them.'

The above scattered observations may be shortly summarized thus:--

1. Bud variations occur in the sugar-cane.
2. They have been recorded from widely separated countries,—Mauritius, Louisiana, West Indies, and Queensland.
3. The difference between sport and mother-plant are often as considerable as those between recognized distinct varieties of the sugar-cane.
4. Bud variation may give rise to:—
   (a) Differently coloured side shoots on one cane.
   (b) Differently coloured canes in one stool springing from the same mother plant.
   (c) A cane with some joints striped and some unstriped.
5. Plants grown from cuttings of the sports tend to come true to colour.
6. The cane giving rise to sports, whenever recorded, has been a striped or ribbon cane.

That bud variation is probably not a very rare phenomenon in the sugar-cane is demonstrated by the case of Arthur Seat plantation. The instances mentioned from that locality were the result of merely one afternoon's observation, and of the canes along the hedge-rows of one field only. Close observation, particularly at cutting time, as suggested by Mr. Horne

would probably result in many more cases being brought to light. Whether many more instances will be brought to notice or not, will depend in the main on the planter. No one observer, however diligent, can closely examine a large area of canes. The labour of getting about, in amongst the mature canes is too great in the tropics, and he will be limited to those cases which happen to occur along the edges of a field. That this is indeed the case is shown by the instance of Messrs. Harrison and Jenman, who during all their long experience with, and careful observation of, the sugar-cane, had not, at any rate up to 1897, ever seen a case of bud variation in the field.

Beyond the interest which attaches to these observations as definitely proving the occurrence of bud variation in the sugar-cane there is the question of their possible economic importance. Previous to the discovery of the seed of the cane, the use of bud variation, or sports, was recommended by the Royal Gardens, Kew, as a possible means of obtaining new and improved varieties of the sugar-cane.

Dr. Morris, in exhibiting the Kirton specimen at the Barbados Agricultural Society, laid stress on its possible economic value. 'One of his principal reasons' he said, 'for coming to the meeting was to try and rouse the interest of planters and get them to look for specimens. If they had a very hardy cane, disease-resisting, and so on, giving out sports, it was quite possible by cultivating a large number of them to get a cane possessing qualities superior to the mother-cane.' Again, at the meeting in July 1899: 'There was a distinct value in these sports, as they afforded a means of obtaining a cane of greater merit than at present. He wished to impress on the Society that the production of sports was not a mere question of curiosity; it was one of very great importance to the Society affecting as it did the raising of new canes.'

The evidence so far available tends to show that many of these sports possess distinct advantages over their parents. It will be remembered that Mr. Horne says, (loc. cit.) on the result of his experience in Mauritius, 'Most of them are hardier than their parents, and yield more sugar'. Mr. J. Clarke, at the end of his letter, an extract from which was given above, says: 'In conclusion I may say that I have also noticed that the yellow sports have a tendency to grow sweeter than the coloured canes of the same family. On analysing purple and yellow sports of the Striped Tanna canes last week, the latter grown in the same field and under similar conditions and receiving exactly the same treatment as the former, showed double the percentage of P.O.C.S.'

In Louisiana, on the other hand, 'Their sugar contents are fully equal to those of our home ribbon and purple canes, over which they have as yet no pronounced excellencies.' (Dr. Stubbs, op. cit.)

Having regard to the possible value of the sports recently obtained in Barbados, it was very desirable that they should be submitted to a strictly comparative test. To this end they have been planted out at Dodds and at Waterford plantation, in the same fields with other canes undergoing test. In each

case the plants from the striped and unstriped canes are growing side by side. On examining them on August 15, 1901, they were still too young to display fully their mature characteristics, but gave every indication of producing striped and white canes respectively.

In the coming crop season, about May 1902, they will be cut, crushed and analysed, and the full results published.

THE DISTRIBUTION OF THE CONSTITUENTS OF THE SUGAR-CANE IN A DEMERARA FACTORY AND THEIR UTILIZATION AS MANURE.

By Noel Deerr.

The following article has for its object the tracing of the nitrogen and ash constituents of the sugar-cane through the factory and the discussion of their possible return to the soil as manure.

Before discussing the main object of this paper it will be well to recapitulate work that has already been done on the composition of the ash of the sugar-cane.

Agricultural chemists have paid considerable attention to the sugar-cane, and many analyses of its ash have been published; those most often met with are sixteen analyses of the ash of West Indian canes made by Dr. Stenhouse. A cursory examination of these shows that the ash of the cane is not of even approximately uniform composition; for example, in Stenhouse's analyses the percentage of phosphoric acid varies from 2·90 to 13·01, of lime from 2·31 to 14·30, of potash from 10·09 to 39·78. Analyses of canes grown in Martinique made by Bonâme show a similar variation.

A very complete account of the nitrogen and mineral matter removed by a crop of cane has been made by Bonâme as the result of work done in Martinique. Following on what has been said above regarding the variation in composition of the ash of the cane, the actual amounts of potash, lime, etc., removed have little or no general interest; the comparative composition of the canes proper and the trash have a more than special interest, as they may reasonably be assumed to show no very great variation. The mean result of the analyses of Bonâme showed that while the canes contained ·3500 per cent. of ash and ·0415 per cent. of nitrogen, the leaves contained 1·6052 per cent. of ash and ·1532 per cent. of nitrogen. The ash of the canes contained 11·76 per cent. phosphoric acid, 9·32 per cent. lime, 18·04 per cent. potash; that of the leaves containing 6·61 per cent. phosphoric acid, 7·64 per cent. lime, 27·58 per cent. potash.

Of four very complete series given by Bonâme no inconsiderable variation in the distribution of the plant food through

the different parts of the crop is shown In two instances where the leaves weighed 34 per cent. of the entire crop they contained two-thirds of the nitrogen, half the phosphoric acid, two-thirds of the lime, and over three-quarters of the potash. In a third case where the leaves weighed 18 per cent. of the entire crop they contained two-fifths of the nitrogen, phosphoric acid, and lime, and half the potash. In a fourth instance where they weighed only 14 per cent. of the entire crop they contained one-third of the nitrogen and phosphoric acid, two-fifths of the lime and over half the potash.

Similar results have been obtained in Louisiana by Mr. R. Glenk, as shown in the following tables taken from Dr. Stubbs' *Field and Laboratory Experiments for ten years.**

MINERAL SUBSTANCES REMOVED PER TON OF CANE, AND RETURNED TO THE GROUND BY THE ROOTS, LEAVES AND TOPS (WHEN TRASH IS NOT BURNED), EXPRESSED IN POUNDS.

Purple Cane.

	Nitrogen.	Phosphoric Acid.	Potash.	Lime.	Mineral Matters.
Total removed by crop .	2·08	1·63	2·52	2·54	44·63
Amount removed by stalks	1·08	1·04	1·22	0·52	11·18
Amount returned to soil	1·00	0·59	1·30	2·02	33·45

Striped Canes.

	Nitrogen.	Phosphoric Acid.	Potash.	Lime.	Mineral Matters.
Total removed by crop ..	2·38	2·07	4·18	2·03	41·50
Amount removed by stalks	0·88	1·30	2·34	0·58	12·40
Amount returned to soil	1·50	0·77	1·84	1·45	29·10

With these figures as a basis of calculation it is possible to calculate the loss to a property where the (in some respects) agriculturally criminal custom of burning the trash before

* A full summary of these experiments will be found in the W.I.B. Vol. I. p. 350 *et seq.* (Ed. W. I. B.)

cutting is carried out. Valuing nitrogen as 7½d. per pound and allowing the trash per ton of cane to head 1·70 lb. nitrogen, an estate of 1,000 acres growing 30 tons of cane to the acre, loses annually in nitrogen £1,594. The practical agriculturist argues on the other hand that the cane cutting is much cheaper. A planter of very great experience, to whom the writer referred the question, estimated the saving in labour as 6s. per acre, which over 1,000 acres comes to £300, still leaving a net loss when trash is burned of £1,294.

Attention has, from time to time, been called to the value of the manures produced within the factory. Lock and Newlands (*Sugar* London, E. & F.N. Spon, 1888) touch upon the subject; they estimate the ash of the megass as 5 cwt. per 100 tons of cane, and its value as 8s per cwt: the filter cake they estimate as 10 cwt. of dry matter per 100 tons of cane, and value at £3: the sediment of the fermenting vats is estimated as 1 cwt. when dry, and valued at 10s.: the lees or 'dunder' when dry is estimated at half a ton, and stated to contain half the mineral matter of the crop and some nitrogen; it is valued at £3. According to this estimate the manurial value of the offal of 1,000 tons of cane is worth £6. 18. 0.

In the *West Indian Bulletin* (Vol. 1. p. 395) is an estimate* of the value of filter dirt as manure: it is there estimated that every ton of cane worked gives 25 lb. of cake, and that 1,000 lb. of such cake contains about 7 lb. nitrogen and 5 lb. phosphoric acid. It is also stated that 1,000 lb. of such cake are equal in nitrogen value to 100 lb. of cotton seed meal, and that it is worth from 1·75 to 2·00 dollars per ton.

Bonâme gives dry filter cake as containing 11·70 per cent. albuminoids, 6·16 per cent. lime, and 3·83 per cent. phosphoric acid, the ash of the cake containing 17·66 per cent. phosphoric acid and 31·56 per cent. lime. An analysis of filter cake quoted by Kruger in *Das Zuckerrohr und seine Kultur* gives the percentage of nitrogen as 1·575, the cake containing 12·79 per cent. water.

The writer has been unable to find analyses of megass ashes and distillery refuse.

With the double object of tracing the ash constituents of the juice through the process of manufacture and estimating incidentally the manurial value of the offal, the writer made the analyses detailed below. They refer solely to the canes as received by the factory; circumstances did not allow of any estimate being made of the amount or composition of the trash; the figures that have already been quoted give sufficient information on that score. The analyses were made over a crop of 30,000 tons of canes; the processes employed were dry double crushing and lime defecation; no phosphoric acid was used. Two sugars were made, but, owing to an exceptionally low purity of part of the juice, about 30,000 gallons of first molasses were distilled.

During the course of the grinding, samples of juice, megass,

* This estimate is quoted from Dr. Stubbs' Louisiana experiments refered to above. [Ed. W. I. B.]

megass ashes, filter cake, lees, etc., were systematically taken and the analysis performed on the carefully mixed sample. The samples of juice of course fermented, and the change in volume, due to this cause, introduced a small and negligible error: the megass preserved was that which had been dried, and thus completely sterilised in the ordinary routine of laboratory control; the weights of juice and megass were obtained from the estates' books; the filter cake was not weighed, but the average weight of a cake was easily found and a tally being kept over a certain time of the number of presses filled gave data to estimate its weight; the lees were taken as equal in volume to the wash distilled, and repeated observations afforded material to estimate the amount of yeast sediment formed in the fermentation.

TABLE I.

	Juice.	Megass.	Canes.	Filter cake.	Sugar I.	Sugar II.	Lees.	Yeast Deposit.
Nitrogen per cent. ...	·052	·028	·045	1·50	..	..	·101	1·96
Ash per cent. ...	·67	1·00	·77	11·55	1·15	3·54	1·79	.
Percentage Composition of Ash:								
Lime ...	1·22	2·41	1·33	17·96	4·73	4·64	6·53	...
Magnesia ..	4·72	2·92	3·96	5·11	2·70	2·95	3·98	..
Potash ...	40·84	16·82	31·23	1·07	39·54	37·26	41·82	...
Soda ...	2·18	1·53	1·92	trace	1·90	1·63	2·32	...
Phosphoric acid	4·97	3·25	4·15	16·77	2·77	3·67	1·61	.
Sulphuric acid ...	15·49	6·22	11·72	1·71	22·60	23·42	20·88	..

TABLE II.

	Total Ash lb.	Lime, lb.	Magnesia, lb.	Potash, lb.	Soda, lb.	Phosphoric acid, lb.	Sulphuric acid, lb.	Nitrogen, lb.
Canes	17,800	205	690	5,380	330	740	2,040	1,010
Used in manufacture	...	850	...	...	.	..	590	80
Juice	10,270	125	480	4,190	220	510	1,590	810
Megass	7,030	170	210	1,180	110	230	440	200
Filter cake ..	1,830	350	95	20	..	310	30	230
Sugar I	1,620	80	48	640	20	45	370	..
Sugar II ..	670	30	20	250	10	25	160	...
Lees ..	7,600	460	300	3,180	180	120	1,560	110
Yeast deposit	..		...	...	.	..	.	195

TABLE III.

	Ash.	Lime.	Magnesia.	Potash.	Soda.	Phosphoric acid.	Sulphuric acid.	Nitrogen.
Canes . ..	100	100	100	100	100	100	100	100
Used in manufacture .	...	288·0					28·9	7·9
Juice .	59·4	42·4	69·6	78·0	66·6	68·9	77·9	80·2
Megass ...	40·6	57·6	30·4	22·0	23·3	31·1	21·5	19·8
Filter cake . ..	10·6	118·6	13·8	0·4		41·8	1·5	22·8
Sugar I .	9·3	26·0	6·2	11·9	6·1	6·1	18·1	
Sugar II	3·9	10·2	2·9	4·6	8·0	8·4	7·8	.
Lees	43·9	155·8	44·1	50·1	54·1	16·2	76·5	43·5
Yeast deposit	...	...	...	...	...	...	...	10·3

In Table I are given analyses of the ash of various products : in Table II the total weight in pounds per 1.000 tons of cane of the ash, nitrogen, potash, etc. ; and in Table III their distribution through the factory products. the quantity in the canes being put equal to 100. Reference to Table I shows that on this particular estate the percentage of lime in the canes was abnormally low, the phosphoric acid decidedly deficient, the potash extremely high, and the nitrogen normal ; though not bearing directly on the main subject of this paper, the inference from these analyses is of such interest as to demand a passing reference. The figures in Table I point, as plainly as a soil analysis, to a great deficiency of lime and to a scarcity of phosphoric acid in the soil ; analyses of soils from this estate made by the writer show a marked deficiency in lime, and in a

less degree in phosphoric acid. In Table III it is seen that nearly three times as much lime is used in the factory as enters with the canes: if the ash of the canes had contained 10 per cent. of lime (Boname gives 9·32 per cent. as the normal figure) these figures would very probably have been reversed, as it is likely that less lime would have been required in the clarification. Of the phosphoric acid about one-third is recovered in the megass ashes, and two-fifths in the filter cake; about one-tenth is lost in the sugars, and less than a fifth find its way into the lees. The lees contain about two-thirds of the potash, and over one fifth is present in the megass ashes and about two-sevenths are lost in the sugars. Of the nitrogen a fifth is burned with the megass, a little less than a quarter being recovered in the filter cake, fully two fifths pass into the lees and a fifth is recoverable in the yeast sediment.

The matter of manurial value that is entirely lost to the soil (though the economical utilisation of the rest is problematical), consists of the nitrogen in the megass and sugars, as well as the ash of the latter, and in certain instances the nitrogen in the trash a point already touched on.

In the valuations detailed below the values adopted by the Massachusetts Experiment Station 1891 have been used. Nitrogen is valued at 7½*d.* per pound, the price fixed for nitrogen in tankage: phosphoric acid is valued at 2½*d.* per pound, the value of this material in wood ashes; potash is valued in the form of sulphate, namely 2½*d.* per pound. On this basis, the 200 pounds nitrogen burnt per 1,000 tons of canes are worth £6. 5*s.*, the 890 pounds potash carried away with the sugar £9. 7*s.*, and the 70 pounds of phosphoric acid lost in the same way 14*s.* Determinations of the nitrogen in the sugars were not made, but the loss here would be comparatively small. The total value of plant food absolutely lost within the factory may then be estimated at £16. 6*s.* per 1,000 tons of cane, and, taking 30 tons of cane to the acre, the loss will be £489 per 1,000 acres.

The next step is to estimate the value of the materials which offer a possibility of recovery: these are taken separately below.

The megass ashes, per 1,000 tons of cane, contained 1,130lb. potash and 230lb. phosphoric acid. On the basis adopted above their value is £14. 8. 0. per 1,000 tons of cane, and £432 per 1,000 acres; per cwt. they are worth 4*s.* 8*d.*

The filter cake obtained was 7·1 tons per 1,000 tons of cane; it contained 230lb. of nitrogen, 310lb. phosphoric acid, and 20lb. potash; its value per 1,000 tons of cane would be £10. 10. 0. and per 1,000 acres £315: per cwt. it would be worth 1*s.* 4*d.*

The lees per 1000 tons of cane contained 3,180lb. potash, 440lb. nitrogen, and 120lb. phosphoric acid; per 1,000 tons of cane they would be worth £47. 2. 0, and per 1,000 acres £1,413.

The yeast deposit contained 195lb. nitrogen per 1,000 tons of cane: it would be worth £6. 1. 0. and per 1,000 acres £181. 10. 0.

The gross value of all of these sources of plant food per 1,000 tons of cane is £78. 10. 0, and per 1,000 acres £2,341. 10. 1.

The subject of pen manure has recently been repeatedly brought forward. In certain cases, this source of manure is very important, but, as circumstances vary within wide limits, an estimate of its value for any particular estate is of no general interest. Where the transport of cane is effected by steam power, no manure can be expected from this source, but in British Guiana and the West Indies generally, where not only is animal power used in transport, but many hundred head of live stock are kept on the estate, a valuable potential source of soil fertilisation can be looked for; many properties utilise this source to a certain extent, but the systematic collection of the excreta of the live stock is not generally practised. For the purpose of completeness, data of the manure produced by different animals are given below; these are abstracted from Aikman's, *Manures and the Principles of Manuring,* where full details regarding the treatment of these manures can be found. With these data, those interested can estimate the value and potentialities of this source for particular instances.

Horse. Per annum 69 to 73lb. nitrogen, 420 to 460lb. mineral matter, the latter containing in the mean about 10 per cent. potash, and 8 per cent. phosphoric acid, and of value about £3.

Mule. No data regarding the value of the excrements voided by the mule appear to be published; the amount will be less than for a horse and might be valued at £2 to £2. 10.

Cow. Per annum 100 to 104lb. nitrogen, 740·8 to 831·5lb. mineral matter, the latter containing about 14 per cent. potash and 3 per cent. phosphoric acid; value per annum about £4. 10.

Pig. Per annum 22 to 27lb. nitrogen, 199 to 281lb. mineral matter; value per annum about £1.

Sheep. Per annum 15·66lb. nitrogen, 96·36lb. mineral matter; value per annum about 12*s*.

In the manufacture of Demerara crystals considerable quantities of phosphoric acid are used; the factory from which these data were obtained was making refining crystals and used no phosphoric acid. Data on this point were kindly supplied from an adjacent factory working practically identical canes. There were used per 1,000 tons of cane 328lb. commercial phosphoric acid; this equivalent to about 135lb. phosphoric acid as P_2O_5 and is of value as manure about 28*s*. or say £42 per 1,000 acres. Analyses of the filter cake and final molasses of this factory were made with the view of determining the distribution of the added phosphoric acid. It was found that the ash of the filter cake contained 16·66 per cent. phosphoric acid, and of the final molasses 7·44 per cent. Comparison with Table I shows that the added phosphoric acid was not present in the filter cake, but found its way into the lees; in making Demerara crystals, phosphoric acid is added to the clarified juice till of slight acid reaction; a soluble superphosphate of lime is probably formed which remains in solution in the juice.

The question that next arises is the economical return to the soil of the plant food removed in the crop; the loss in nitrogen due to burning the trash has already been

touched on; the connexion of trash banks with the presence of moth-borer and fungoid disease lies without the province of this paper.

The application of the filter cake offers no difficulty; it occurs naturally in a form readily and easily handled.

Many planters affirm that the application of megass ashes causes a growth of grass, and for this reason do not apply them although they are rich in both potash and phosphoric acid. It should be mentioned too that the whole of the megass ashes are not available; a large proportion of clinker which, without preliminary treatment to reduce it to powder would be valueless, is formed; the powdery ash which is taken from the flues and falls through the fire bars is however in a state readily applied, and provided it does not too much promote the growth of grass offers no obstacle to its use. The composition of megass ashes must be very similar to those produced on burning trash; the latter procedure is generally believed to produce a healthy and vigorous 'spring' and the application of megass ashes containing a store of readily available plant food should act in the same way.

Mention has been made above of the yeast deposit: this source of nitrogen does not appear to be generally touched upon and requires some explanation. In the factory from which these data were obtained, the fermentation was almost invariably performed by the agency of a highly cell reproductive yeast; nearly every vat fermented was covered with a thick layer of a spongy mass of yeast cells; on an average it was estimated that for every 100 gallons of wash fermented, there were produced 2·5 gallons of yeast, estimated by volume; per gallon of yeast there were 1·13 lb. of solid matter of which ·106 lb. was nitrogen, the dry matter containing 13·70 per cent. of nitrogen; there is then here contained a source of a highly concentrated organic nitrogenous manure; in general practice, no attempt is made to collect it, but it is allowed to run to waste. The yeast might be collected as it is, and applied in its natural state, or it might be passed through a filter press and formed into cakes containing say 50 per cent. to 60 per cent. of water when it would contain about 6 per cent. of nitrogen; from data obtained per 1,000 gallons of wash, about 30 lb. of pressed yeast would result, and from 1,000 acres about 20 tons.

The material which offers the greatest difficulty, with regard to economical treatment, is the lees or distilling refuse; as every one living in the vicinity of a sugar plantation knows, the lees become at times a serious nuisance. The following schemes suggest themselves as possible methods for their utilisation:—

1. The concentration of the lees to small bulk and utilisation as manure.

2. The destructive distillation of the concentrated lees, the collection of the products of distillation and incineration of the residue to obtain the potash salts.

3. Irrigation of the cane fields with the lees.

4. Precipitation with lime and collection of the precipitat-

ed phosphates and nitrogenous matter and utilisation as manure.

5. Bacterial treatment.

6. Collection of the lees in ponds and subsequent excavation and application of 'lees mud' as manure.

7. Disposal of lees as cattle food.

The concentration of the lees to a density of 1·25 would mean the evaporation of 90 per cent. of the weight of the lees; to do this evaporation, there would be required a multiple evaporator of modern and economical design; an estate of 2,000 acres growing say 30 tons of cane per acre would distil 1,500 gallons of wash per hour; to concentrate the lees, a triple evaporator of not less than 2,500 square feet heating surface would be necessary. Although there may be some few factories which could supply steam to perform this extra evaporation without burning extraneous fuel, there are few, if any proprietors, who would allow the initial capital cost. Besides, the viscid material which results would not in itself be in a form suited for manuring, and the scaling in the evaporator would be enormous.

In beet factories, the lees from the beet spirit distilleries, known as 'vinasse' or 'schlempe' is sometimes evaporated to dryness and destructively distilled in closed retorts. In the distillate are obtained trimethylamine, methyl alcohol and ammonia; the residue in the retorts is treated to obtain the potash salts. The question of fuel expense at once prevents the application of such a scheme in a West Indian factory. On an estate in Demerara a number of years ago a system of lees irrigation was put on trial: the trial was never completed, as, unfortunately, the distillery was burned down and the estate abandoned as a separate concern. This method of disposal appears one of the most rational; as is well known, liquid manuring whenever practicable is the most efficacious form.

With regard to liquid manuring, the great objection is the bulk of material to be dealt with, so that means to collect the valuable constituents are naturally looked for. Lees, when allowed to settle, give a considerable deposit, and, when treated with lime, give a copious precipitate. It was found by direct experiment that, to completely precipitate 1,000 gallons of lees, 150lb. of commercial temper lime were necessary; on 1,000 acres, this would mean from 65 to 70 tons of lime. After treatment with lime, lees that originally contained ·0104lb. nitrogen per gallon, now contained ·00406lb. per gallon, showing that about 60 per cent. of the nitrogen was precipitated. On filtration a sludge in volume about 15 per cent. of the lees treated was obtained; the precipitated matter when dry contained 3·82 per cent. of nitrogen. The treatment of lees in this way would require no expensive outlay, the sludge obtained might be used direct or passed through filter presses and formed into a solid cake. The sludge filters easily, and, when dry, forms a dirty grey easily pulverised material; the cakes would hold about 50 per cent. of water and would contain about 1·9 per cent. nitrogen: per 1,000 acres 130 tons more or less of such cake would be obtained, of value for the

nitrogen alone of £170. This method of treatment would still leave the potash to run to waste.

The bacterial treatment of lees, considered as sewage, need not be discussed here: the process is still in the controversial stage, and at best only deals with the disposal and not the utilisation of sewage.

At present in the West Indies the method of treating the lees is to run them into a pond or blind trench; this pond which in time becomes a mass of soft black mud is in some cases dug out and the mud applied to the cane fields; very great loss in drainage occurs, and the handling of so bulky a matter is uneconomical.

The utilisation of lees as cattle food need not be considered in the absence of any market for their disposal.

There remains to be considered the manures produced by the live stock. Wherever possible, the stock should be stalled at night and their excrements systematically collected. Generally speaking this source of manure is not neglected, but not so complete a use is made as is possible. The treatment of pen or stall manure is too large a subject to be touched on here and reference should be made to any good treatise on agricultural chemistry.

Since this article was written, a paper on the treatment of "burnt ale" from whisky distilleries has appeared.* The problem discussed by the author is substantially the same as that touched on in the latter part of this paper. It is further stated that 'burnt ale' is not injurious to vegetation, and its disposal as manure is strongly advocated: treatment with lime in the proportion of 30 lb. per 1,000 gallons, and collection of the precipitate, is brought forward as a means of disposal: in general 'burnt ale' is richer than lees in phosphates, poorer in potash, and contains about the same amount of nitrogen.

In conclusion, I would remark that the figures brought forward above deal only with one particular plantation: on another estate, growing canes with an ash of different composition, very different figures might be obtained; but, as tending to show that a sugar estate might be made a self-manuring system, independent of the aid of extraneous manures, the composition of the ash is immaterial.

PLANTING AND CROP SEASONS OF SUGAR-CANE IN THE WEST INDIES.

THE planting and reaping (crop) seasons of the sugar-cane, in common with those of most other cultivated plants, are controlled largely by conditions of soil and climate. Throughout such a large area as the West Indies, including in this term all the British Colonies from Jamaica to British Guiana, these conditions naturally vary very considerably. They some-

* James Hendrick. *Journal of the Society of Chemical Industry.* May 31, 1901.

times vary in different portions of the same island, particularly of Jamaica. As canes are frequently sent from one Colony to another it is important to know the general planting season for each Colony. To this end a circular letter was issued requesting a short account of the planting and crop seasons in the various islands and British Guiana. Extracts from the replies received are given below. The name of the person supplying the information is given in each case in brackets. At the conclusion of the article the scattered items of information are summarized in a general table for more ready comparison.

JAMAICA.

Planting Season.

Parish.	Part of the Island.	District.	Planting Season.
Westmoreland	South-west.	Savanna-la-Mar.	August to May.
Trelawney ..	North.	Duncans.	October to January.
St. James .	North-west.	Little River.	December to January.
St. Thomas-in-the-East. .	South-west.	Morant Bay.	September to November.
Clarendon ...	South (middle)	Chapelton, (northern part of parish.)	July to August.
Clarendon ..	South.	Vere, (southern part of parish.)	July to August. November to January.

Crop Season.

Parish.	Part of the Island.	District.	Crop Season.
Westmoreland	South-west	Savanna-la-Mar.	November to May.
Trelawney	North.	Duncans.	January to June.
St. James ...	North-west	Little River.	January to July.
St. Thomas-in-the-East. ...	South-west	Morant Bay.	January to May.
Clarendon ..	South (middle)	Chapelton, (northern part of parish.)	January to May.
Clarendon ...	South.	Vere, (southern part of parish.)	January to May.

Notes. —In the Savanna-la-Mar district 'planting is carried on all the year round except June and July, but fall planting is more certain than spring planting. Fall planting allows fifteen months for the canes before crop time.'

In Little River district, 'canes are ratooned for ever with a little supplying yearly; but any planting would be done in December to January to get the light rains which come in December to February.'

In Morant Bay district 'plants put in in September to November are all advanced and cover the ground by March when a spell of dry weather is expected.'

In the Chapelton district the 'plants are well established before the heavy rains come on: if planted later they might be too small and likely to be injured by the rains.'

In Clarendon 'all our canes are allowed twelve months' growth at least before cutting.'

(J. BARCLAY.)

BRITISH GUIANA.

Planting Season.

'Canes are planted here at different times according to the seasons; probably the best time to replant is during the May and June grinding, as then it is possible to give the plant canes fourteen to sixteen months' growth. But much planting is done in December and January, where it has not been feasible or convenient to plant in the middle of the year.'

Crop Season.

'In one part of the Colony or another, estates are nearly always working. There are, however, two main crop seasons, one during the early part of the year, say principally in May and June, and a longer one towards the end of the year in September, October, November, and December.'

(J. B. HARRISON.)

TRINIDAD.

Planting Season.

'The season for planting commences after the August rains have ceased and continues through to December, or until the crop season commences in January or February. This period employs estate hands during the time a large proportion of them are not required for cane cutting and factory work.'

Crop Season.

'The crop season 'lasts from January to May.' During this time 'the field operations are at their minimum and available field labour is employed chiefly for supplying and weeding. Sometimes the crop season extends to the month of June and seldom terminates until the rains enforce a stoppage owing to the difficulty of field transit.'

Notes.—'Canes planted in the season from September to December will be cut in the harvest season of the second year following, *i.e.* if canes are planted in September 1901 they will be harvested in the crop season January to May 1903; and if cut say in March, will then be fifteen months old.

'The planting and supplying of fields goes on however at any season when it is found possible to employ the field hands economically at such work.'

(J. H. Hart.)

St. Vincent.

Planting Season.

'The best months for planting sugar-canes in St. Vincent are:

(*a*) October, on Scoriae soil.

(*b*) December, on Clayey soil.'

Crop Season.

'March, April and May.'

(H. Powell.)

St. Lucia.

Locality.	Planting Season.	Crop Season.
"Grand Cul-de-Sac"	October to January. .	January to May.
"Roseau" . ..	October to December	January to May.
"Vieuxfort" ..	October to December	January to May.
"Dennery" ..	February to May ...	February to May.

Remarks.

'October is generally considered the best month for planting, even by the Dennery managers, who plant in crop time in order to secure good plants, and avoid throwing land out of cultivation. (G. S. Hudson).

BARBADOS.

Planting Season.

'The planting season usually commences about the middle of November and continues to the end of January of the next year. In some few instances canes are planted as early as October and also as late as February, but the greater portion of the planting is done between the beginning of December and the middle of the January following.'

Crop Season.

'The commencement of the crop season depends to a great extent on the weather conditions, but as a general rule the crops are begun about the middle of February and are finished about the end of June. The estates in the low-lying districts finishing about a fortnight earlier.' (J. R. BOVELL).

ANTIGUA.

Planting Season.

'I would suggest that December to February be taken as the average planting season for sugar-cane.' (F. WATTS).

'Beginning of December to the end of March,' at Belvidere (late district). (A. SPOONER).

'Beginning of November to the end of February at Montpelier (limestone district.)' (A. SPOONER.)

Crop Season.

'The reaping period varies according to the season, being particularly influenced by the rainfall. In an early season reaping would begin in the first week in February, in a late one it may not begin until three or four weeks later. The time of finishing reaping will vary too from the end of June to the end of July.' (F. WATTS).

'At Belvidere, middle of February to middle of June.' (A. SPOONER).

'At Montpelier (limestone), the middle of January to the end of May.' (A. SPOONER).

ST. KITTS.

Planting Season.

'The planting of sugar-cane in St. Kitts is usually begun during October and is continued up to and during March, the greatest activity in this direction being during the months of December and January. Mountain lands are usually planted later than others so that the canes may be growing vigorously during the arrowing season (October and November), and in this way the arrowing of the cane is to some extent prevented.'

Crop Season.

'Reaping is usually begun in December, but, owing to abnormal causes, such as disease, or canes having been allowed to stand over from the previous crop, it is sometimes begun in November. It lasts, on large estates, without interruption until June; March is considered the best month for producing sugar, the juice being usually of a higher density during that month.' (W. LUNT).

MONTSERRAT.

Planting Season.

'For lands below 600 feet elevation from October to December. For mountain lands (above 600 feet elevation) from February to April.'

Crop Season.

'From February to June.' (A. J. JORDAN.)

GENERAL SUMMARY.

LOCALITY.	PLANTING SEASON	CROP SEASON.
Jamaica:		
South-west ...	August to May ...	November to May.
North ...	October to January ..	January to June.
North-west ...	December to January	January to July.
South-west ...	Septr. to November ...	January to May.
South (middle)	July to August ...	January to May.
South ...	July to August November to Janry.	January to May.
British Guiana ..	May and June and December and Jany.	May and June and Septr. to Decr.
Trinidad ...	August to December or later ...	January to May.
St. Vincent ...	October (Scoria soil) December (Clay soil)	March to May.
St. Lucia ..	October to January ...	January to May.
Barbados ...	December and January	February to June.
Antigua ...	November to March ...	January to July.
St. Kitts ...	October to March ...	December to June.
Montserrat ...	October to December (high lands) February to April (low lands)	February to June.

SOUR-GRASS.

(*Andropogon pertusus*, Willd.)

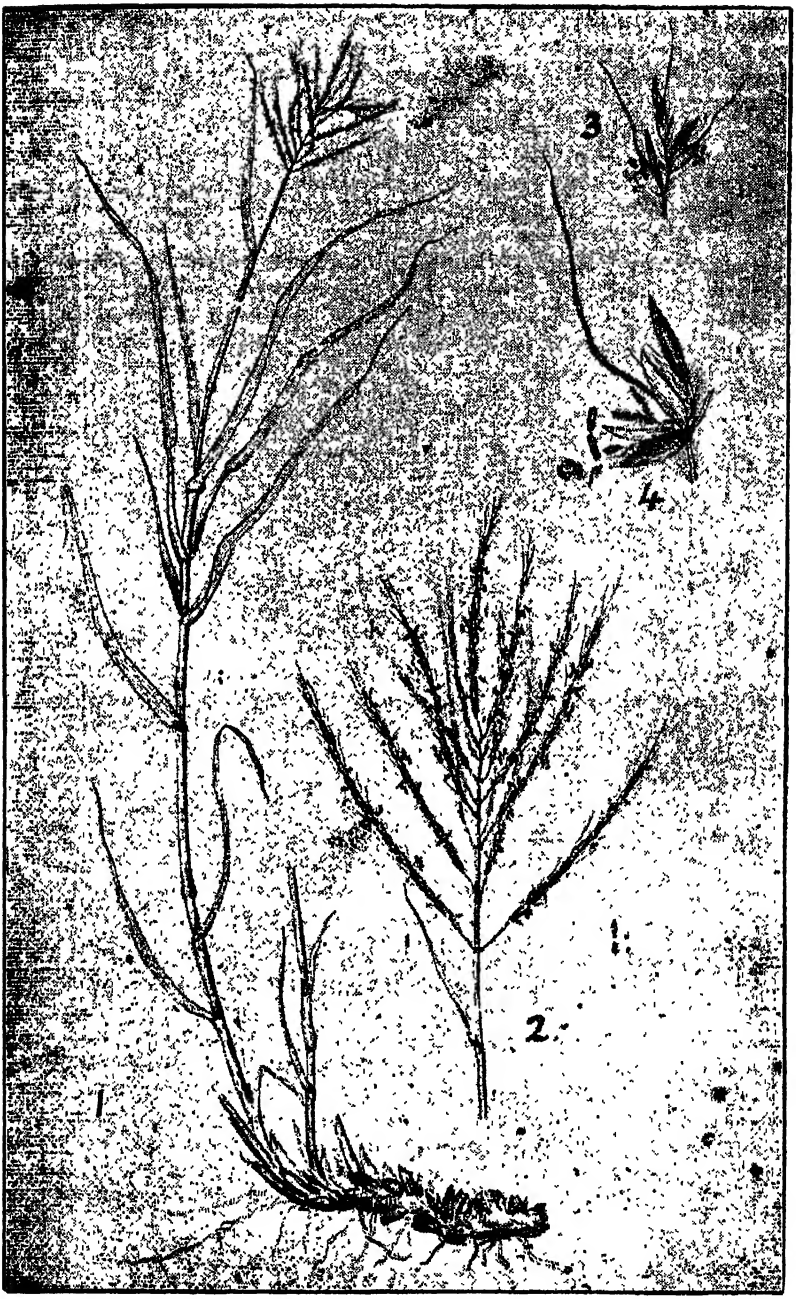
The grass commonly known as 'sour-grass' or 'Barbados sour-grass' in many parts of the West Indies, is *Andropogon pertusus*, Willd. a native of India. The 'sour-grass' of Jamaica, which forms the excellent 'low bite' pasture in the low-lying parts of the island, is a perfectly distinct grass. *Paspalum conjugatum*, Berg, a native of the West Indies whence it has been introduced into many tropical and sub-tropical countries. The present article deals only with the Barbados sour-grass, *Andropogon pertusus*.

The genus *Andropogon*, to which this grass belongs, is one of the largest genera in the family of grasses, and contains some 180 species, distributed almost all over the world but especially abundant in warm countries. Amongst other grasses of economic interest belonging to this genus may be mentioned, khus-khus grass, *A. squarrosus*, Linn; lemon grass, *A. Schoenanthus*, Linn.; citronella grass, *A. Nardus*, Linn.. The Guinea-corns and millets are by some authorities included in the genus *Andropogon* (in the sub-genus *Sorghum*). By other authors *Sorghum* is made into an independent genus.

Andropogon pertusus has recently been described by Sir J. D. Hooker in Vol. V of Trimen's *Flora of Ceylon*. A comparison, by Mr. J. R. Bovell and the writer, of his description with typical fresh plants has revealed no important points of difference between Ceylon and Barbados specimens. Sir J. D. Hooker queries it as an annual in Ceylon; however that may be there is no doubt about its perennial character in the West Indies.

The following description is practically that of the *Flora of Ceylon*, with such minor alterations as were required:

Perennial: rhizome, slender, creeping; stem 1 - 1ft. erect or ascending, slender, leafy upwards, simple or sparingly branched, nodes occasionally bearded, upper internodes filiform; leaves narrow, lower short and crowded at the base of the stem, all narrowly linear, up to a foot long and ¦ in. broad, flat, tips of upper capillary, glabrous, or sparsely ciliate, margin scaberulous, base rounded, upper sheaths long but shorter than the internodes, terete, lower shorter compressed, mouth hardly auricled, ligule a short ciliolate membrane: spikes 3—14 subdigitately racemed, sessile or lower shortly peduncled, 1—2 in. long, slender sub-erect, flexuous, rhachis filiform fragile, and pedicels villous with white hairs; spikelets ⅙ in. long, longer than the internodes, oblong lanceolate, pale callus villously bearded with long hairs; sessile spikelet fem, glume I. obtuse or minutely truncate, thinly-chartaceous, usually with a large deep pit about the middle, 5—9 veined sparsely hairy towards the base, margins narrowly incurved, subspinulosely ciliate; II. lanceolate, acuminate, tip exserted beyond I., obscurely keeled above the middle, glabrous or ciliate, 3 veined; III. shorter, linear



BARBADOS SOUR-GRASS.
(*Andropogon pertusus*, Willd.)
1. Whole plant (reduced). 2. Infloresence. 3. Group of spikelets. 4. Fertile and sterile flowers.

oblong, obtuse, veinless; IV. the narrow colourless base of the slender subgeniculate awn, which is $\frac{1}{2}$ - $\frac{3}{4}$ in. long, and slightly rough; palea O; pedicelled spikelets like the female: but narrower, pedicel more than half as long as the sessile spikelet; glume I. acute, very rarely pitted.

Sir J. Hooker records the grass as occurring in 'all warm countries of the Old World extending to the Mediterranean.'

The value of this grass has long been recognized in various parts of the world. Duthie in his *Fodder plants of Northern India* says: - 'This grass, which is met with all over the plains of Northern India, is universally esteemed as a good fodder grass, both for grazing and stacking. In Australia also it is highly valued, being regarded as one of the best grasses to stand long droughts, while it will bear any amount of feeding. It is useful also as a winter grass if the weather is not too severe.'

In Watt's *Dictionary of the Economic Products of India*, Vol. I., p. 219, Dr. Stewart is quoted as follows:

'It is considered excellent fodder for bullocks, etc, and for horses when green.' While Mr. Coldstream of Hissar, adds: 'Good for stacking, will remain for 12 or 13 years; much stacked at the Hissar farm. Is especially grazed by buffaloes.'

Dr. Voelcker in *Improvement of Indian Agriculture* (1893), p. 173, speaks of the same grass as follows: -

'Unless where distant forests are concerned, or where "reserves" are sufficiently large to permit of grazing, I am in favour of grass being cut and removed rather than of its being fed off by stock. At *rukh Jellche* (near Changa Hanga) the people pay one rupee for the privilege of cutting and removing one head-load of grass each day during one month. At the Etawah "reserve" the grass is cut by a contractor, and is sold on the spot for $\frac{1}{4}$ anna per head-load of about 100lb.; this is sold at 2 annas in the village, and the price in Cawnpore is 6 annas. The grass is principally "palwa" (*Andropogon pertusus*) a good feeding grass.'

In the *Flora of Ceylon* it is reported as being 'an excellent fodder grass, green or dry.'

The history of its introduction into the West Indies does not appear to be known. Maycock in his *Flora Barbadensis* published in 1830, records it as *Andropogon angustifolius*, with 'narrow leaved sour-grass' as one of its vernacular names, but makes no observations as to its origin. Whenever first brought to Barbados, the grass has now become thoroughly established and forms pastures many acres in extent. It is of especial value inasmuch as it thrives on dry, exposed limestone hills, unsuited for cane cultivation, but which make valuable grazing lands for the estate cattle.

The following account of sour-grass in Barbados was contributed by Mr. J. R. Bovell to the *Kew Bulletin* for 1895:

'The "sour-grass" is the chief fodder grass of this island, where it is cultivated almost to the exclusion of all others. In the driest districts and on the most exposed places this hardy and excellent fodder plant, which grows from 18 inches to 2

feet high, seems to thrive and be at home, furnishing, at the time of the year when other fodder is scarce, food for the animals employed on the sugar estates. If cut shortly after it flowers, just as the fruit is setting, it forms valuable food for horses, cattle and mules, who then seem to eat it with relish; but if it is allowed to get over-ripe the stems become hard and unpalatable, the animals then only eating the leaves and tender parts unless it is chaffed up and given them with the addition of oil-cake and molasses. It is propagated by root cuttings, the cuttings being placed in holes about 1 foot apart each way, when it soon spreads, covering the whole surface of the land. It goes on ratooning for many years, giving two, and sometimes three, cuttings annually The yield varies with the soil, rainfall, and manurial treatment, but the average yield, without manure, may be set down from 5 to 7 tons per acre per annum; with the application of manure the yield is greatly increased, an acre then giving from 10 to 12 tons of fodder yearly. Until recently an acre of fairly good unmanured sour-grass was worth £3 for the first cutting and £2 for the second, the purchaser paying cost of cutting and loading. Lately, however, owing to the depreciation of the value of land, due to the fall in the price of sugar, an acre of sour-grass may be purchased for from £2 to £1 per acre for the two cuttings.'

The refreshing appearance of the Barbados pastures attracts very general notice, and several efforts have been made to introduce Barbados sour-grass into some of the other islands. Mr. C. A. Barber, in a paper on the Antigua grasses, published in the *Supplement to the Leeward Islands Gazette*, October, 1894, notes the existence of sour-grass in various localities in Antigua, and recommends that more care should be paid to it. Describing the appearance of the grass, he says:—'Fields of the grass after rain remind me, by their fresh green colour, more than anything else in the tropics of the English meadows.'

He also records its successful introduction into Nevis by the Hon. Joseph Briggs who 'has sown some large fields in Nevis with sour-grass. These are on a light volcanic soil. The grass is protected by being fenced in so that different parts may be fed to the cattle at different times. The primary difficulty with regard to the taste of the grass was got over by simply turning the cattle into the enclosed fields. The Nevis cattle when I last saw them were thriving very well on it.'

Some years ago the Rev. G. Branch introduced sour grass on his estate at 'Pointe Saline' in Grenada. The estate is situated on the sea coast at the south end of the island in probably the driest locality in Grenada. The grass thrives there very well, and Mr. Branch regards it as a valuable fodder grass for his stock. In 1896 Mr. G. Whitfield Smith planted sour-grass at Bellevue estate, in the same island, but on the windward side, at an elevation of 1,600 feet, in deep red soil. He reports that the plants lived for some time, but were weak and sickly and apparently not suited to those conditions. The

plant is now growing abundantly and doing well at various localities in Grenada.

With regard to other West Indian islands, the grass does not appear to be of any economic importance in Trinidad, as it is not mentioned in either of Mr. Meaden's papers on 'Trinidad Grasses' in Vol. ii. of the Proceedings of the Trinidad Agricultural Society.

A patch of the grass is reported to have established itself at 'The Fort,' Tobago. and it is also said to occur at Olveston estate, Montserrat. In Barbados the grass forms large pastures, on which cattle are successfully raised.

Beyond its value as green fodder, it is a good grass for making hay. The weight of hay obtained from a given quantity of the green grass is very high, as is seen by comparing the percentage of water in sour-grass with that in four other common pasture grasses in Antigua. These results were obtained by Mr. F. Watts, and published in the *Kew Bulletin* for 1896 : -

	Percentage of Hay.	Percentage of Water
Andropogon pertusus (Sour-grass)...	60	40
Chloris barbata	35	65
Andropogon caricosus (Hay grass)	30	70
Panicum prostratum (Cent. per cent. grass)	21	79
Panicum colonum (Rice grass) ..	18	82

Mr. Watts also made a chemical analysis of the hay and from the figures so obtained calculated the composition of the fresh grass :

CHEMICAL ANALYSIS OF SOUR-GRASS.

	Composition of Hay.	*Composition of Fresh Grass.*
Water	10·92	10·55
Ash.	5·50	3·30
Nitrogen (total)	0·808	0·484
Crude protein	5·05	3·03
Albuminoid nitrogen	0·70	0·420
True protein	4·378	2·626
Fibre	29·75	17·85
Nitrogen, Free Extract ...	37·71	22·62
Fat	2·075	1·245

INSECTIVOROUS BIRDS.

Throughout the West Indies an enormous amount of damage is annually done to crops as the result of insect attacks. In Antigua crops such as green-dressings, cassava, corn and sweet potato, are often almost entirely eaten up by caterpillars. In Barbados the sweet potato, and green-dressings are, occasionally, similarly eaten off. In St. Vincent, at certain seasons of the year, the arrowroot industry is threatened with extermination owing to the armies of caterpillars which attack the plant. The damage done by this pest culminated this year in the eating up of between two and three thousand acres of arrowroot. In St. Kitts grasshoppers have recently been a serious pest.

No one reason can be assigned as the cause of the present state of affairs, but in all probability the introduction of the mongoose into many of the West Indian islands has been an important factor. The mongoose is commonly looked upon as being responsible for the apparent recent diminution in the numbers of some birds and lizards in various localities in the West Indies; in particular, are ground-nesting birds subject to its attack. Lizards and many birds are insect eaters and any diminution in their numbers would probably result in an increased abundance of the creatures on which they normally feed.

As indicative of the connection between the mongoose and insect plagues, the present condition of Barbados, Antigua and Montserrat affords an interesting object lesson. The general conditions, climatic and otherwise, of these three islands are fairly similar and they grow practically the same crops, yet Antigua abounds in insect pests whilst Barbados and Montserrat are comparatively free. In Montserrat the mongoose has apparently never been introduced, lizards are extremely abundant and insect pests unimportant. Antigua is overrun with mongoose, as also by insect pests. Previous to the introduction of the mongoose, birds and lizards are stated to have been numerous, amongst the former being the 'quail' or 'bob-white' (*Orthyx Virginianus*) a ground-nesting bird. With the diminution in numbers of the birds and lizards, the insect pests have increased. In Barbados the mongoose is moderately abundant. The island is on the whole comparatively free from insect attack. Sweet potato and green dressings having it is true suffered this year, but the damage done is much less severe than in Antigua. The important point of difference seems to be the presence in Barbados of the 'black bird'—a distinctly insectivorous bird, which, owing to its nesting in trees, is safe from the mongoose.

In general two methods of dealing with such insect pests are possible. In the first place we may attack the pest directly, catching, or poisoning the mature insect, collecting the eggs, or adopting such other methods as appear suitable, taking into question the life-history of the pest and local circumstances. On the other hand we may attack it indirectly, by protecting and fostering, if possible, its native enemies, or, if ne-

cessary by introducing enemies, or probable enemies, from other localities.

In the case of insects the introduction of insectivorous birds is one of the remedies most commonly suggested, and at times adopted. When successful this method is doubtless the best possible, constituting a permanent, natural remedy. On the other hand the introduction of the wrong bird may cause much more damage and expense to the community than the pest it was employed to eradicate and for this reason it seems well to bring together here the experience of other countries on this important point.

The question of the introduction of foreign insectivorous birds into the West Indies was recently brought forward owing to the plague of grasshoppers in St. Kitts. The damage done by these insects in that island can be clearly realized from the following summary of a report by Mr. Lunt, the Curator of the St. Kitts Botanic Station. He states that: 'The prevalence of grasshoppers in St. Kitts has been more noticeable during the present year [1900] than during former years. Some planters have taken measures to protect themselves against the depredations of these insects by employing children to collect them, and as many as fifty or sixty thousand have been caught in a week on one estate. The price paid was at first one penny per hundred, but this was afterwards reduced by half on account of the enormous numbers which were caught.

'They are found in large numbers in all the cultivated parts of the island, but are most abundant on cane lands. In some cases the greater part of a field had to be replanted on account of the damage caused by them.'

Besides attacking the canes he says that they also eat the young shoots of green dressings etc., so that a field had sometimes to be replanted several times.

The West India Committee suggested to the Colonial Office that it might be advisable to consider the question of the introduction of the Indian myna, and that an inquiry be made into the habits of the bird with a view to finding out whether it would be suitable for the purpose.

This suggestion of the West India Committee was referred to Mr. E. W. Oates, author of *The Birds of India*, and to Dr. P. Sclater, F.R.S., Secretary to the Zoological Society of London. The correspondence was also forwarded to the Department of Agriculture for the West Indies. In a letter of December 17, 1900, to the Colonial Office, Dr. Morris reviewed the reports of the damage committed in St. Kitts by the pest, indicated the action already taken by the Department in the matter, and in regard to the proposal to introduce the Indian myna said:—

'I would advise extreme caution in taking action in this direction. The late Sir Edward Newton, K.C.M.G., Lieut. Governor of Jamaica informed me that this, or a closely allied bird, had been introduced some years ago into Mauritius and it

had proved almost as great a pest as the English sparrow in the United States, or the rabbit in Australia. It had driven away the smaller and more interesting birds, and was regarded as altogether an undesirable and useless introduction.

'I doubt whether any bird could be so useful at St. Kitts as the common blackbird of Barbados. This I am informed by Mr. Maxwell Lefroy, is useful in destroying caterpillars on sweet potato and other crops, and it might be tried to destroy, at least, the grasshoppers in the wingless stage.'

The replies received from Mr. Oates and Dr. Sclater are given in full below :–

Mr. Eugene W. Oates, to Sir Charles E. Bernard, India Office, London.

1, Carlton Gardens,
Ealing, W.
November 29. 1900.

Dear Sir Charles,

I am very glad to be able to give you some information on this subject. The talking mynas (*Eulabetidæ*) are I think, almost entirely frugivorous and would not do for the purpose you mention.

There are certain mynas in India, however, which are extremely common, easily caught, hardy and living almost entirely on ground-insects, such as locusts and grasshoppers. I was too much pressed for space in my book on Indian birds to make much reference to habits, food, etc. I think the following species would thrive well in the West Indies, and if they did not clear the country of grasshoppers, they would do much towards it.

No. 544, vol. 1. p. 533 *Temenuchus pagodarum*, the Black-headed Myna.
No. 549, vol. 1. p. 537 *Acridotheres tristis*, the Common Myna.
No. 551, vol. 1. p. 538 *Acridotheres ginginanus*, the Bank Myna.
No. 555, vol. 1. p. 542 *Sturno pastor contra*, the Pied Myna.

These four species are very widely distributed in India and could be caught in large numbers at a small cost. They would, I think, stand the voyage well, and they would thrive in any tropical part of the world.

I do not think any species of starling proper would thrive in the tropics. The Indian mynas are the birds required in the West Indies. Mr. Frank Finn of the Indian Museum, Calcutta, would, I am sure, greatly interest himself in this matter and would have the birds caught and despatched by ship under the care of competent men. The experiment should not cost much.

I am, &c.,

(Sgd.) EUGENE W. OATES.

Dr. P. L. Sclater, Secretary Zoological Society of London, to the Under-Secretary of State for the Colonies.

Zoological Society of London,
December 12, 1900.

Sir,

In further reply to your letter of November 27, (38,087/1900) I beg leave to inform you that having considered the subject of Mr. Aspinall's letter and consulted other members of the Society on the question, I have the following remarks on it to offer to Mr. Secretary Chamberlain :—

As a general rule naturalists of the present day are opposed to advising the introduction of animals from foreign parts into other countries, because they disturb the 'balance of nature' and are more likely to do harm than good. Notorious examples of this fact are the 'rabbit-pests,' in Australia and New Zealand, and the 'English-sparrow plague' in North America. At the same time there may be exceptions to the rule.

The Indian Starling alluded to, in Mr. Aspinall's letter is probably the Indian Mynah (*Acridotheres tristis*) of India, which was successfully introduced, in the last century, into the islands of Bourbon and Mauritius, and still exists there, it is said, in large numbers. By some authorities this bird is stated to have been of great benefit to the agriculturists in these islands, on account of it destroying the grasshoppers. Other authorities however do not speak so favourably of it. I therefore venture to recommend that, before taking any practical steps in the matter, advice should be sought from the Colonial authorities in Mauritius, and their views ascertained on the subject.

Another authority which it might be well to refer to on this subject, is the Board of Agriculture of the United States, under the control of Dr. C. Hart Merriam, who has had great experience with locusts and grasshoppers.

I have, &c.,

(Sgd.) P. L. SCLATER,
Secretary.

Acting upon the advice of Dr. Sclater, the Colonial Office instituted inquiries in the United States and Mauritius, with the following results : —

Lord Pauncefote, to the Marquis of Lansdowne, K.G.

Washington,
February 12, 1901.

My Lord,

I have the honour to report that, in accordance with the instructions contained in your Lordship's despatch No. 5 of the 4th. ultimo, I addressed a note to the United States Secretary of State, requesting his good offices to obtain from Dr. C. Hart Merriam of the United States Department of Agriculture, an expression of his opinion as to the advisability of introducing the Indian starling into St Kitts, for the purpose of combating the grasshopper pest in that island.

I have now the honour to transmit a copy of a letter addressed to Mr. Hay by Dr Merriam embodying his views on the subject from which it appears that the contemplated measure is not to be recommended on account of certain habits of the bird.

I have requested Mr. Hay to convey to Dr. Merriam my thanks for the information contained in this letter.

I have &c.,

(Sgd.) PAUNCEFOTE.

Dr. C. Hart Merriam, United States Department of Agriculture, to The Hon'ble John Hay, Secretary of State.

United States Department of Agriculture,
Biological Survey,
February 1, 1901.

Sir,

In reply to your letter of January 30, respecting the proposed introduction of the Indian starling on the island of St. Kitts, as a means of combating the grasshopper pest, I beg to submit the following.

The mina (sometimes spelled mynah) or Indian starling has not been introduced into this country, but has been introduced, and is now abundant in the Hawaiian Islands. It feeds on insects and fruit and is consequently both beneficial and injurious. At Honolulu it is in very bad repute, and its introduction is universally regretted. It is a very noisy bird and thousands are said to congregate in the evening to roost in the palms and other trees where their inharmonious cries prove a source of much annoyance. They drive pigeons out from their houses and destroy the eggs and young of both domesticated and wild birds. This is the worst charge against them and it is one of considerable weight An eminent ornithologist believes that the extermination of some of the interesting native birds of the Hawaiian Islands is attributable to the nest-plundering habits and great abundance of the mina birds. From accounts it appears that the species multiplies rapidly like the English sparrow and that there is great danger of its becoming an overwhelming pest.

As a general rule, it is unsafe to introduce exotic birds or mammals into a new region except in the case of the larger species which can be held in check if necessary. It is much better to encourage the increase of native species which already prey upon injurious insects. The introduction of turkeys and Guinea fowl, on the other hand, is a perfectly safe measure, and has the advantage that these birds are themselves of much value for food. They are among the most efficient destroyers of grasshoppers, and owing to their large size consume vast numbers of these insects. Regretting my inability to give you more information on this point.

I remain &c.

(Sgd.) C. HART MERRIAM,
Chief, Biological Survey.

Mr. Daruty de Grandpre, Superintendent of the Museum of Mauritius, reported on the effect of the introduction of the 'martin' or Indian starling, (*Acridotheres tristis*) upon agricultural conditions in Mauritius and as a measure for destroying locusts. In the course of his lengthy report, he quotes many older accounts of the great damage done to locusts in the island and of the efforts made to destroy them, and in conclusion says: —

'We believe that we have sufficiently proved that the martin has cleared Mauritius from the swarms of locusts and has greatly reduced the number of all other insects to such a point that Bory de St. Vincent could write in 1801: They have ruined "the entomological fauna of the island.'

'That bird is very precious to agriculture and should deserve to be protected and introduced into all countries that are liable to the same scourge as that which devastated our island in the last century.

'It may be objected that martins eat many fruits and are a cause of trouble to pigeon houses where they try to get entrance, breaking eggs and killing young pigeons in order to lay their eggs during the months of September to February, but we think that those little injuries are of small importance when compared with the important and valuable services they render to agriculture.'

M. Grandpre's report is therefore distinctly favourable to the bird. On the other hand, M. P. Boname, Director of the Station Agronomique of the same island, in his annual report for 1898-9 also discusses the question of insectivorous birds, and his remarks on the martin may be briefly summarised thus: 'The martin enjoys a false reputation as an insectivorous bird; it is rather graminivorous and frugivorous than insectivorous. When feeding its young it certainly does kill some locusts, but also small lizards and other animals, themselves insect eaters.' He quotes the late M. Raoul to the effect that the myna is frugivorous by instinct, graminivorous by taste, and only insectivorous from sheer necessity.'

In the Colonial Report on St. Helena for 1900 p. 10, the following passage occurs: -"A few Indian mynas, let loose a couple of years ago, have multiplied to a great extent, and the farmers tell me that they are in constant attendance on the cattle, freeing them from ticks. The birds do a little damage in fruit gardens, but they compensate for this by the number of insects they destroy. The importation of other insectivorous birds has not been attended with success.'

Briefly to review the above experiences we find: 'At Honolulu the myna is in very bad repute, and its introduction is universally regretted.' In Mauritius according to one observer it 'is very precious to agriculture' and its introduction into a locust-ridden country is recommended. At the same time the damage done by the bird to the fruit and pigeons demands notice. In the same island according to the second observer quoted 'it enjoys a false reputation as an insectivorous bird' being 'graminivorous and frugivorous

rather than insectivorous.' In St. Helena 'the birds do a little damage but compensate for this by the number of insects they destroy.'

The evidence on the whole seems against the bird. The report from the Hawaiian Islands is distinctly adverse; the favourable opinion of M. Grandpre in Mauritius is evidently not shared by M. Boname; and in St. Helena a certain amount of damage is recorded to mar an otherwise favourable account.

The history of the introduction of some other insectivorous birds is very similar. Reference need only be made here to the English sparrow in America, New Zealand, Australia, Bermudas and other localities, and the English starling in Western Australia, and Tasmania.

The natural conclusion to draw from these facts seems to be that the introduction of an insectivorous bird from a distant country is to be looked upon as a last resort. An insectivorous bird, however useful in its native country, is very likely to become a nuisance when introduced into a new land. In the absence of its natural enemies, and under perhaps very good conditions, it may increase with great rapidity and possibly, changing its habits, feed almost exclusively on fruit and grain instead of on insects.

Attempts should rather be made 'to encourage the increase of native species which already prey on injurious insects,' or, if there are none, to introduce a bird of well-known habits from a place where its conditions of life are very similar to those under which it will have to live; or where it is probably exposed to the same or very similar enemies.

To put the matter shortly, it would apparently be very inadvisable to introduce a bird, like the myna, from the East into the West Indies, until it has been demonstrated that there is no West Indian bird suitable for the purpose.

In Barbados one of the first birds to draw attention to itself is the 'blackbird' (*Quiscalus crassirostris*), a glossy black bird, with a strong beak, about the size of an English blackbird. It is constantly to be seen on vegetable grounds, gardens, etc., catching and eating insects. The same bird is recorded from Jamaica, where it is known as the 'tinkling grackle.'

In Barbados, recently, the sweet potato has been subject to the attack of the 'sweet potato worm,' the caterpillar of *Protoparce cingulata*, and in a report of a visit to an infested area, Mr. H. M. Lefroy says 'Large numbers of "blackbirds" may be seen in the fields; two of which were shot and dissected. The stomach of one contained only remains of potato worms, and the stomach of the other contained parts of the potato worms and of two other insects.'

The Department recommended the introduction of this bird into St. Kitts, and accordingly birds were shipped from Barbados to that island.

Concerning their import Mr. Lunt reports as follows :—

'Four consignments of Barbados blackbirds have been received here from the Imperial Department of Agriculture: 15 birds were advised on the February 4 last, 10 on the March 18 last, 31 on the April 1 last, and 23 on the May 14 last, making a total advised of 118 birds. Some of the birds died during the passage, but I am unable to give the exact numbers as no record was kept during my absence. The first consignment was divided between Pond, Needsmust and Estridges estates; the second lot was distributed between Willets, Molyneux, Fountain, Estridges, Pond and Needsmust Estates, and Springfield House; the third lot between Needsmust and College estates, and the last lot between West Farm, and Fountain estates, and the Botanic Station.

'From the last consignment Mr. Dobridge, of West Farm estate, received six birds which he intended for Nevis.

'The birds distributed show an inclination to congregate in numbers at one spot, as at Brighton estate only two birds were loosed, and very shortly three others made their appearance.

'It is interesting to note that some six years ago twenty one blackbirds were introduced from Barbados by the Hon'ble E. G. Todd of Buckleys at his own cost; two pairs migrated to Camp estate, Mr. W. Berridge took care of these, and they have steadily increased in numbers, and the community now numbers some twenty-six birds.

'Observations as to the habits of the birds have been made, at the Botanic Station, and at Brighton estate. They have been seen to attack and destroy grasshoppers, in some cases catching them during flight, whilst in captivity they eat grasshoppers greedily.'

From what Mr. Lunt states, confirmed by the experience of planters, the birds are admirably adapted for the object in view, and they are not likely to disturb the balance of life in the island.

With such a useful bird as the Barbados blackbird immediately to hand, and whose introduction is not likely to be attended by any great damage in the future, it seems very undesirable to seek further, and introduce perhaps such a bird as the myna, which, whatever value it may be at the first, will, judging by the experience of other countries, become a serious pest in the near future.

NOTE ON THE FORMATION OF CANE-SUGAR IN THE SUGAR-CANE.

BY WILLIAM G. FREEMAN, A.R.C.S., B.Sc. F.L.S.,

Technical Assistant to the Imperial Department of Agriculture for the West Indies.

Cane-sugar is a substance which occurs in nature in many plants, and some of those plants which contain it to a large degree, and are adapted to cultivation, have become of great economic importance. At the present day, the two plants most extensively grown for the cane-sugar they contain are, as everyone is aware, the sugar-cane and the sugar-beet. The one object of the planter of either is to produce the greatest possible amount of cane-sugar per acre, and on this account, if for no other, it is of interest to draw attention to the present state of our knowledge concerning the formation of cane-sugar in plants. This subject has been previously dealt with,* but since 1891 a great deal of work has been done and the views then held considerably modified. The comment in this paper, 'Yet it is remarkable how little has been done to thoroughly investigate the life-history of the sugar-cane and to ascertain the most favourable conditions for the formation of cane-sugar in its tissues' is almost equally true of the present day. In the present article an attempt will be made to give a brief general account of the formation of sugars and related substances in plants and the uses to which they are put, so far as we know at the present day, and to apply this general knowledge to the case of the sugar-cane.

The juice expressed from a ripe sugar-cane contains dissolved in it a number of substances, the most important of which are cane-sugar (or sucrose) and glucose. Many plants contain very little sugar in their tissues and in these we usually find starch. Others again are like the sugar-beet, which contains large quantities of starch in its leaves but stores up cane-sugar in its roots. The very extended observations which have been made, show that the majority of plants form starch or some kind of sugar. The first question to answer is: How comes this sugar or starch, as the case may be, in the tissues of the plant? To solve this question satisfactorily, it is necessary to know something of the chemical composition of sugars and starches.

CHEMICAL COMPOSITION OF SUGARS AND STARCHES.

Starch and the various sugars belong to a large group of substances known as carbohydrates. The significance of the technical word —carbohydrates— may be realised from the following comparison. Water is not a simple chemical substance, that is to say, it can be broken up into still simpler bodies, and we find that by suitable means the liquid, water, can be split up into two gases, oxygen and hydrogen. Moreover, in a given quantity of water, the volume of the hydrogen is double that

*Production of cane-sugar in the sugar-cane. *Kew Bulletin*, 1891, p. 35.

of the oxygen. In chemical terms this is expressed by saying that one molecule of water contains two atoms of hydrogen and one of oxygen. Using the ordinary chemical symbols we can denote the composition of water by the formula H_2O—hydrogen two atoms, oxygen one. Similarly carbon dioxide, or carbonic anhydride can be expressed by the symbol CO_2 the element carbon itself being represented by C. We get therefore :-

Carbon	C	carbon alone.
Carbon dioxide	CO_2	carbon one atom. oxygen -two atoms.
Water	H_2O	hydrogen—two atoms. oxygen—one atom.

Exact chemical analysis of the sugars and starches has resulted in chemists assigning to them the following formulae :—

Starch.	$C_6 H_{10} O_5$	or	carbon 6 atoms. hydrogen - 10 atoms. oxygen—5 atoms.
Glucose	$C_6 H_{12} O_6$	or	carbon—6 atoms. hydrogen—12 atoms. oxygen—6 atoms.
Cane-sugar or Sucrose	$C_{12} H_{22} O_{11}$	or	carbon—12 atoms. hydrogen—22 atoms. oxygen—11 atoms.

Examining these formulæ more closely, we see that starch contains six atoms of carbon, ten atoms of hydrogen and five atoms of oxygen. But ten atoms of hydrogen and five atoms of oxygen combined together would make five molecules of water, so that starch apparently contains six atoms of carbon united with five molecules of water. Similarly glucose contains six atoms of carbon united to six molecules of water ; and cane-sugar, twelve atoms of carbon united to eleven molecules of water. All these three bodies therefore consist essentially of carbon, hydrogen and oxygen united together, the two latter elements being present in the same proportion as they are in water. This relationship is conveniently expressed by the term carbohydrate.

The sugar-cane, as indeed any other plant, (with the exception of parasites, receives usually no carbohydrates in its food. When growing in the ground it takes up, by its roots, water with substances such as nitrates, phosphates, potash and lime in solution, and if this were all the food it obtained it would be impossible for the plant to form carbohydrates. Whence then does a plant obtain its carbohydrates ? We shall see that plants manufacture carbohydrates from the carbon dioxide contained in the air, and the water which they take up by their roots. This process is carried on by the protoplasm—the actual living substance of the plant—contained in the leaf, in the presence of sunlight and the green colouring matter of plants. The steps by which these facts have been demon-

strated may be best followed by briefly tracing the historical development of our knowledge on the subject.*

FORMATION OF CARBOHYDRATES IN PLANTS.

As far back as 1670, the Italian botanist Malpighi put forward the view that the leaves are of great importance in elaborating food material. About 1727, Stephen Hales, F.R.S., an English clergyman, demonstrated that plants derive a great deal of their substance from the air. In 1772 the English chemist Priestley (the discoverer of oxygen), observed that green plants took up carbon dioxide from the air, and gave out oxygen. Ingen-Houss (an Austrian physician who also practised in London) showed, in 1779, the great importance of sunlight, pointing out that green shoots and leaves only exhale oxygen in sunlight or bright daylight. In 1801 the Swiss chemist Theodore de Saussure made the very important observation that during the process of taking in carbon dioxide and giving out oxygen, plants increased in weight.

The three workers Priestley, Ingen-Houss and de Saussure, between the years 1772 and 1801, established:—

1. That the green parts of plants take in carbon dioxide from the air and give out oxygen

2. That they only do this in sunlight.

3. That this process is accompanied by an increase in the weight of the plant.

The establishment of the fact that the carbon dioxide is taken in by the green parts of plants—the leaves in particular—did away with the older view which Malpighi shared, that the roots took up carbon dioxide, which then travelled up the stem to the leaves.

These facts represent practically all that was accurately known with regard to this subject at the beginning of the Nineteenth Century. To understand more easily later developments it is necessary to digress for a while to the consideration of the internal structure of a leaf, because the next notable advances were due primarily to microscopical observations.

STRUCTURE OF LEAVES.

A typical leaf consists of an expanded thin plate of tissue, supported and spread out to the air and light on a framework of leaf veins. The complex network of the veins is readily seen in a 'skeleton leaf.' They penetrate to every part of the leaf and coming together at the base join on finally to the woody tissue of the stem.

The work of manufacturing plant food goes on in the soft tissue of the leaf. The veins, in addition to supporting this tissue, are the channels whereby water with minerals in

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*For many of the historical facts, the following works have been consulted and made use of without detailed reference:—
Sachs. *History of Botany*. Eng. Trans. 1890.
Vines. S. *Physiology of Plants*.

solution is brought up to the leaves from the roots, and the material elaborated in the leaf carried away to other parts of the plant. By cutting an extremely thin slice of a leaf, and examining it under the microscope it is found that the soft parts of the leaf consist of a more or less spongy mass of cells, which contain large numbers of small, often oval, green bodies to which the colour of an ordinary leaf is due. These green bodies are the chlorophyll granules. They are made up of protoplasm (the living substance of the plant), and permeated by an oily colouring substance—chlorophyll or leaf-green. The upper and lower side of the leaf are covered by a layer of cells usually containing no chlorophyll, but penetrated by minute openings—the leaf pores or stomata—by means of which air can pass into the inner cells of the plant.

The bodies of importance to us now are the chlorophyll granules.

FORMATION OF STARCH IN CHLOROPHYLL GRANULES.

The famous German botanist Hugo von Mohl was engaged about 1870 in some investigations as to the nature of chlorophyll granules, and he showed that they contained starch grains. He also observed that the starch grain was not an original part of the chlorophyll body, but was a later development in it. Other botanists confirmed his observations, but no explanation was offered of the connection between chlorophyll body and starch grain until Sachs took up the question, which he treated in his usual masterly manner.

Julius von Sachs, Professor of botany at Würzburg, was investigating the conditions which regulated the decomposition of carbon dioxide in green plants, and the fact that no decomposition took place in the absence of chlorophyll led him to investigate the structure of the chlorophyll granule. After very careful experiments he demonstrated that the presence of starch grains in chlorophyll bodies is dependent upon exposure to light. The facts proved so far may be summarized thus :—

1. Green plants can decompose carbon dioxide.

2. They only do this in sunlight.

3. The power of decomposing carbon doxide depends on the presence of chlorophyll.

4. Starch is formed in connection with chlorophyll granules.

5. Starch is only formed in chlorophyll granules after exposure to sunlight.

Thus it is seen that the conditions under which the chlorophyll granules decompose carbon dioxide are identical with those under which they form starch. Sachs therefore concluded that the formation of starch and the decomposition of carbon dioxide are directly connected. If this view is correct it should follow that normally growing green plants, exposed to light but in an atmosphere containing no carbon dioxide, cannot form starch. Experiments made to settle this question by two other workers conclusively showed that under these conditions no starch is formed in the chlorophyll granule.

FURTHER HISTORY OF STARCH IN THE PLANT.

So far we have established that green plants under the action of sunlight and in the presence of carbon dioxide, can form starch grains in their chlorophyll granules. It remains now to determine what becomes of this starch and to what purposes it is put by the plant. It is easy to show that the leaves of many plants, such as a hibiscus or a tobacco plant growing under ordinary conditions contain abundance of starch in the afternoon of a sunny day. After say twelve or twenty-four hours subsequent exposure to darkness they have no starch in their leaves. A simple experiment to prove this is to remove one half of a leaf which has been exposed to the sun, leaving the other half on the plant. Test the cut off part for starch, and if present in abundance put the whole plant in complete darkness for twenty-four hours. Then cut off the half leaf left on the plant. This in most plants will be found to contain no starch. We have learnt already that no fresh starch* is formed in leaves whilst in darkness, but the leaf has apparently used up what starch it had. Now, starch is not easily dissolved; it forms a paste, but it does not really go into solution, and in plants only substances actually in solution can pass from one cell to another. The starch in the experiment above must either have been used up in the cell in which it was formed or altered into some soluble substance and carried away to another part of the plant.

As the result of much research, into the details of which it is not essential to enter here, the following view of the formation and subsequent fate of starch in the plant came to be put forward. Starch grains are formed in the chlorophyll bodies in the leaves of growing plants exposed to the light and to an atmosphere containing carbon dioxide. The latter substance being broken up, the carbon retained by the plant, and the oxygen given out. The amount of starch formed increases during exposure to light and decreases during exposure to darkness. Sachs considered that in any given cell of the leaf two independent processes went on. Firstly, the formation of starch, which only took place during day-light; and secondly, the further solution of the starch and its subsequent transference to other parts of the plant. He considered that these two processes went on simultaneously, and that starch accumulated in the leaf cells during the day because more was formed than could be carried away. To quote Sachs' own words on this point:* 'The starch arising in the chlorophyll by assimilation is continually being dissolved in the light, as well as in the dark, and conveyed into other parts of the plant. During vigorous assimilation its accumulation in the chlorophyll predominates: in continuous darkness or feeble illumination, on the other hand, the solution and translocation of the starch prevails and it is this which renders it possible to deprive the chlorophyll granules of starch for experiment purposes.'

* To do this boil the portion of leaf in water for about two minutes. Place in alcohol until all the green colour is extracted, and then immerse in weak iodine solution. If starch is present the leaf becomes of a dark greenish blue colour.

* Sachs. *The Physiology of Plants* (English translation) p. 313.

Dr. Weber, one of Sachs' assistants, conducted experiments to determine the actual amount of starch formed during the day and carried off during the night. One of the plants which he experimented upon was the common sun-flower, from which he got the following results:

	Grammes † of starch.
Gain per square metre* of leaf in 10 hours of the day...	9·14
Gain per square metre per hour ...	0·914
Loss per square metre of leaf in 10 hours of the night	9·64
Loss per square metre per hour ...	0·964

On Sachs' view that the loss of starch from the leaf goes on through both day and night, the gain during the day represents not the total amount of starch formed, but only the excess beyond what the plant can remove from the leaf. The actual amount of starch formed per hour of the day can therefore be obtained by adding together the gain during the day and the loss during the night. The experiment quoted indicated that 1·878 grammes of starch were formed in every square metre of the leaf per hour of daylight.

Two important points remain to be discussed with regard to Sachs' theory.

1. Is starch actually the first product of the activity of the chlorophyll granule?

2. Does all the carbohydrate material manufactured in the leaf pass through the form of starch?

It will be more convenient here to deal with the second question first. In 1893 an epoch marking paper appeared by Messrs. Horace T. Brown, F.R.S., and G. H. Morris, Ph. D., entitled *A contribution to the chemistry and physiology of foliage leaves.*‡ The results now to be brought forward are based on their work. Amongst other questions, Brown and Morris re-investigated the increase and decrease in weight in a sun-flower leaf during day and night. Their figures are very similar to those obtained by Sachs. It will be remembered that Sachs considered that the whole of the increase during the day was due to starch: this Brown and Morris inquired into. They were able, by utilising better chemical methods than Sachs had at his command, to show that the actual increase in amount of starch might be very small, whilst the leaf increased considerably in weight. Thus, in one experiment they obtained 0·718 grammes as the gain in one square metre of sun-flower leaf per hour. But during this same time the increase in starch in one square metre of the leaf was only 0·12 grammes. If therefore they say (*loc. cit.* p. 633) "Sachs view is correct, that all the assimilated products pass through the form of starch, the

† One gramme=15·4 grains. 28·3 grammes=1 oz. Avoirdupois.
* One metre=39·37 inches. 1 sq. metre=1·196 sq. yards.
‡ *Transactions of the Chemical Society of London*, Vol. lxiii, pp. 604—677.

formation and dissolution of that substance must take place at a most astonishing rate.'

Not only too must the formation and dissolution take place at this extraordinary rate, but they must be going on together, and in one and the same leaf cell we must suppose the building up and dissolving of starch grains to be taking place simultaneously. This is in itself a sufficiently serious theoretical objection to demand a re-investigation of the question. The research which was carried out was a very exhaustive one, and a general resume of the results is all that can be attempted here.

SOME POINTS ESTABLISHED BY MESSRS. H. T. BROWN AND G. H. MORRIS.

1. By means of a series of experiments conducted on the leaves of *Tropaeolum majus*, the 'nasturtium' or 'Indian cress' of gardens, they demonstrated that a sugar was formed before starch as a result of the activity of the chlorophyll granules. They further indicated that this sugar was cane-sugar.

That a sugar was possibly formed previously to starch had indeed been suggested by Sachs himself. On page 318 of his Physiology he says, quoting from an earlier paper:—'If after all, I regard the starch in the cell as one of the first products of assimilation, it is not therefore to be said that carbon dioxide and water unite forthwith to form molecules of starch within the chlorophyll substances, oxygen being evolved...... I am now [1865] strongly inclined to assume that both in the assimilating chlorophyll corpuscles and in the non-assimilating starch corpuscles, the material for the formation of starch consists of sugar.'

2. They also showed the presence in the leaf cells of a ferment known as diastase, which has the power of acting on starch, converting it into a sugar called maltose Diastase had been previously known, for instance it is formed in considerable quantities in the barley grain during its germination, and by its action the starch, stored up in the grain and of no immediate use to the plant as a food, is converted into the sugar maltose, which being soluble can be carried to any part of the young barley plant and used. Similarly, diastase occurs in a sprouting potato. In fact, it is commonly found wherever starch has to rendered soluble, and the important point to notice here is that it was shown to be present in the leaf cells.

3. Diastase is formed more abundantly in leaf cells during the night, when they are not assimilating, than during the day.

As a general result of their work the following is a possible explanation of what goes on in the leaf.

Cane-sugar is the first product of the activity of the chlorophyll granules, and is the starting point of all the later

changes taking place in the leaf. The cells of the leaf require a certain amount of food for their breathing and other processes, and probably use up some of the cane-sugar as it is formed. Some more of the cane-sugar may be carried away immediately to other parts of the plant. It is possible therefore to conceive a leaf cell which forms just as much cane-sugar as it can either use itself or get rid of immediately. If however, assimilation is very active more cane-sugar may be formed than can be got rid of at the moment, and cane-sugar will then tend to accumulate in the cell. Under these conditions the chlorophyll granules commence to form *starch*, from the previously made cane-sugar, and *to store it up as a temporary reserve.*

This formation and local storing up of starch continues to go on whilst assimilation is very active, with the result that at the end of a sunshiny day the leaf cells may be packed with starch grains.

During the night, assimilation entirely stops, and the plant for such food material as is required for its breathing and other processes will probably soon use up the amount of cane-sugar available. This failing, it draws on the temporary 'bank reserve' of starch, converting it by means of the ferment diastase, into the soluble sugar maltose, which can readily be carried about to any part of the plant, whilst starch cannot. Part of the starch therefore which is temporarily stored up during the day, will be used up for the life processes of the plant during the night. What is not so used is generally also carried away from the leaf and stored up, as a more permanent reserve, in some other part of the plant, as in tubers, bulbs, rhizomes, seeds, etc. The form which the reserve of carbohydrate matter takes varies in different plants. For instance in the potato tuber, it is starch; in the onion bulb, it is grape sugar (glucose); in the stem of the sugar-cane and the root of the beet, it is cane sugar.

The storing up of starch in an underground part of a plant, such as a potato tuber which contains no chlorophyll, might be looked on as proof that starch can be formed in the dark, without the presence of chlorophyll. So in fact it can; it is made here by small bodies, similar to the chlorophyll granules, but destitute of chlorophyll and called starch corpuscles or leucoplastids. The difference in function between the two has been thus aptly summarized* by Dr. D. H. Scott, F.R.S.: 'Both in the chloroplastid and in the leucoplastid, starch is produced at the expense of sugar. The difference between them consists in the origin of the sugar, which in the former case is the result of the assimilation of inorganic compounds, whilst in the latter it is derived from pre-existing carbohydrates.'

The important points of the views of Sachs, and Brown and Morris, may be summarized thus:—

SACHS' VIEW.

1. Starch is the first visible product of assimilation (possibly a sugar is previously formed).

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* *Structural Botany (Flowering Plants)* p. 213.

2. The starch is carried away in soluble form, through both day and night.

(Some used for the immediate needs of the plant.)

3. Remainder stored as reserve of

(*a*) Soluble substance such as sugar.
(*b*) Insoluble „ „ „ starch.

VIEW BASED ON BROWN AND MORRIS' WORK.

1. Cane-sugar the first visible product of assimilation.

(Some used for immediate needs.)

2. The excess stored in the leaf cells, in which formed, as a temporary reserve of starch.

3. Starch by action of diastase converted into sugar (maltose) and removed from leaf during night.

(Some used for immediate needs of plant.)

4. Remainder stored as reserve of

(*a*) Soluble substance such as sugar.
(*b*) Insoluble „ „ „ starch.

The most important point of difference is that in Sachs' view all the carbohydrate material elaborated in the leaf passes through the from of starch, whilst in the latter view the formation of starch is only a side issue, taking place when assimilation is so active that more material is being formed than can either be carried away at once or made of immediate and local use.

It is necessary to point out that the work of Messrs. Brown and Morris has only been carried through in all detail for one plant. Scattered observations, however, would suggest that in at any rate a great number of plants, sugar, even if not always cane-sugar, is formed previously to starch. Many plants form little or no starch in their leaves, some form none.* The common onion is a marked example, producing extremely little starch in its leaves. In the sugar-cane itself very little starch is formed, and that usually confined to a ring of cells around the veins of the leaf. It is possible that in many of these plants the sugar is carried off from the cells practically as fast as it is formed, and the necessity for storing starch temporarily in the leaves does not arise. Evidence in support of this view is afforded by the fact that the leaves of some of these plants, exposed to bright light in an atmosphere containing more than the usual amount of carbon dioxide, do form starch grains in their chlorophyll corpuscles. Under these conditions assimilation is increased, apparently more carbohydrate material is formed than can be carried away at once, and the plant is forced to temporarily store up the excess in its leaves as starch.

ROLE OF CANE-SUGAR IN THE LIVING PLANT.

It now remains to consider the part played by cane-sugar

* Investigations on this question have comparatively recently been made by Mr. J. Parkin, M.A. A paper "Contributions to our knowledge of the formation, storage and depletion of carbohydrates in Monocotyledons" appeared in the *Philosophical Transactions of the Royal Society*, for 1899, Series B. Vol. 191, pp. 35—79.

in the living plant. and in particular in the sugar-cane. It might be supposed that, as cane-sugar is an exceedingly soluble substance it would be carried away from the cells where it is formed and utilized directly for the needs of the plant. Whilst the evidence at present to hand is somewhat conflicting, it would appear that many animals and plants are not able to utilize cane-sugar directly. For instance, the French physiologist M. Claud Bernard showed that if cane-sugar is injected into the blood of an animal it is of no use for nutritive purposes, but is excreted as cane-sugar in the urine. On the other hand, introduced into the alimentary canal it is of undoubted value as a food. He found that in the small intestine a ferment invertin* is present, which converts the cane-sugar into equal parts of glucose and levulose, which can be made use of by the animal protoplasm.

Bernard then investigated the beet. During the first year of the beet's life it forms starch in its leaves, the excess of which is converted into cane-sugar and stored up in the root. The leaves die down with the approach of winter. and the root remains in the ground loaded with a great reserve of plant food in the form of cane-sugar. The sugar planter digs it up at this time and appropriates the sugar to himself. In the natural course of events the beet would, in the following spring, put up a new crop of leaves, and finally flower and form seed. The formation of seed is a great drain on a plant's resources, for each seed carries a reserve of food for the young plant it contains. The beet uses up in its seed formation all the carbohydrate material its new crop of leaves makes in the second year, as well as the reserve put by from the first year, so that the store of cane-sugar in the root gets gradually less and less as flowering advances.

Bernard found that it is not cane-sugar which travels up from the root to the flowers, but glucose ; and he was able to demonstrate the presence in the beet of a similar ferment to the invertin he had found in animals. Thus apparently in the plant as in the animal, cane-sugar needs to be converted into some other form before it can be used by the living protoplasm.

Since Bernard's time invertase has been shown to be widely distributed in plants, and, amongst others, Brown and Morris demonstrated its presence in the cells of the leaf.

In general, cane-sugar in plants (apart from the question of its being the first product of assimilation or not) must be looked on as a reserve, put by when the plant is making more carbohydrate material than it requires for its immediate needs to be drawn upon later for some effort which demands a large amount of food such as flowering and the formation of seed. Cane-sugar in some plants, as starch in others, may be spoken of as the 'bullion' or banking reserve.

ROLE OF CANE-SUGAR IN THE SUGAR-CANE.

From what has been already said the cane-sugar in the stem of the sugar-cane must be looked on as a reserve of plant food.

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* In plants the term invertase is usually employed.

Probably in the wild sugar-cane and nearly related plants this reserve is used up during flowering and the subsequent ripening of the seed. The cultivated sugar cane is grown under unnatural conditions: many varieties rarely flower at all and others produce a comparatively small amount of seed. The cultivated sugar-cane does not therefore actually require all the sugar it stores up, but what may be looked on as the original habit of the plant still remains, and even if not going to flower at all, it stores up sugar for the stage in its growth at which, growing wild, it would have flowered.

So far as I am aware, the first product of assimilation in the sugar-cane leaf has not yet been exactly determined. Certainly very little starch is formed, and what is found in the cane leaf is not present in the chlorophyll-containing cells but in the ring of non chlorophyll-containing cells which surround the leaf veins.

It may well be that a sugar is the first product, perhaps cane-sugar, or possibly some other sugar, such as glucose. At present, judging by the results of research on other plants, one inclines to the view that cane sugar itself may be the first product of the activity of the chlorophyll granules in the sugar-cane. One might then suppose that this cane-sugar—probably after conversion into glucose and levulose—is carried away: some to be used in the actively growing parts, young buds, etc., and the surplus to be re-converted into cane-sugar and stored up in the stalk as a reserve of plant food.

Such analyses of the cane as have been made show that the youngest joints contain glucose but no cane-sugar. As the joints mature, the percentage of glucose gradually diminishes and that of cane-sugar increases. From what is known to take place in other plants it seems probable that the glucose found in the young portions of the cane is not actually formed there. In opening buds and other actively growing parts the consumption of plant food is far in excess of the production, and they have to be supplied from other parts of the plant. The glucose found in them may then be derived from sugar manufactured in the mature leaves. So much requires to be done with regard to the processes in the sugar cane that it is impossible at present to put forward such a working hypothesis except with the greatest caution. The steps above outlined are very similar to those which have been established for the sugar-beet, excepting that the cane produces scarcely any starch in its leaves.

From this sketch it will readily be gathered that much work remains to be done before we can, with any certainty, describe the actual steps in the manufacture and utilization of cane-sugar in the sugar-cane. Amongst other points, we require to know the first product of assimilation; the true relationship to each other of glucose and cane-sugar. All that has been attempted here is to give some idea of the possible sequence of events, from what we know already of the cane and of other plants more thoroughly investigated.

JAMAICA FRUIT TRADE.

The starting of a direct fruit trade between Jamaica and the United Kingdom is an event of great importance to the West Indies.

The following account which appeared in *The Times* of August 30, 1901, from its Special Correspondent, is reproduced, by permission, in the pages of the *West Indian Bulletin*:

The direct transport of bananas in bulk from Jamaica to the United Kingdom was inaugurated early in March, when the *Port Morant*, the first steamer of the Imperial Direct Service, left Kingston for Avonmouth with a full cargo of fruit. The bananas reached England in excellent condition so far as the effect of transit was concerned.

STORAGE CONDITIONS.

The appliances for ventilating the holds in which the bananas were stowed and for maintaining a uniform temperature were found to work admirably, and when the fruit was unloaded it had undergone little or no deterioration in transit. The steamers of the new line have since made regular voyages at intervals of a fortnight, and I understand that the satisfactory experience of the first voyage of the *Port Morant* has been repeated and even bettered. I returned from Jamaica in the *Port Morant* on her second homeward voyage. In the course of the passage I visited the fruit chambers more than once, and inspected the more accessible of the many thousand bunches of bananas stowed therein. So far as my observation went they were all in good condition, ripening slowly and uniformly, but showing no signs of over-ripening, none of serious damage, and none whatever of decay. A few of the fingers--a single fruit is called a finger---had been slightly bruised in handling, the rind being partly discoloured, but this is rather a blemish than an injury, and is often seen on the fruit brought to table even in Jamaica.

ABSENCE OF ODOUR IN TRANSIT.

I have heard it said in some quarters that bananas are a very unpleasant fruit to carry in passenger steamers, that the odour they emit in the process of ripening is strong, persistent and unsavoury, and that it pervades the ship to the great annoyance of her passengers. I can only say that the atmosphere of the fruit chambers in the *Port Morant* was as sweet and fresh as it was on deck, and in tropical latitudes a great deal cooler. I doubt if the nose of any passenger could have told him that there was a single banana on board, though he might have been aware that the sugar planters of Jamaica had availed themselves of the direct service to ship rum in considerable quantities to England. I have travelled in a mail steamer with apples from Tasmania and with cocoa from the West Indies. I would gladly have exchanged the companionship of either for that of bananas from Jamaica. *De non apparentibus et non existentibus eadem est ratio.* The odour of apples and the odour of cocoa were obtrusively and persistently apparent throughout the voyage. The odour of bananas was, to my nostrils at any rate, entirely non-existent.

CONDITION ON ARRIVAL.

Thus the mere problem of transport, and of inoffensive transport, in a first-class passenger steamer, across 4,000 odd miles of sea, was practically solved from the outset, and further experience has, I understand, since bettered the solution. I am not here concerned with the problem of distribution and sale in England, about which there is more to be said than I am competent to say. But there is one point connected with the market for Jamaica bananas in this country about which some misapprehension has arisen which it is worth while to dispel. It is no use bringing bananas from Jamaica to England unless when they arrive they are acceptable to the consumer and readily saleable at a price which yields a fair profit to the importer. There is a problem here which was certain to prove more difficult of solution than that of transport pure and simple. It is not insoluble, for it has been solved, in spite of similar difficulties, in the case of bananas from the Canaries; but it was not, perhaps, completely solved in the case of the first cargoes of bananas from Jamaica. The fruit as placed upon the market was pronounced in some quarters to be insipid and immature. I daresay it was—indeed, it could hardly be otherwise when an entirely new experiment had to be tried. No one could tell, until experience had yielded up the secret, at what precise stage of maturity the banana should be cut from the plant in order that it might be just ripe and ready for market—neither immature nor over ripe—after a transit of some 14 days. It was necessary in the first instance to ascertain that a transit of 14 days would neither arrest the ripening of the fruit nor consign it to premature decay. This was placed beyond a doubt by the first few voyages, but it still remained to ascertain the precise stage of maturity at which the fruit should be cut in order that it might be just ready for sale and consumption at the time of its arrival. I do not think this

problem was completely solved in the first few cargoes, and this goes far to explain the insipidity and immaturity of which some critics complained.

WHEN TO CUT BANANAS.

The banana is peculiar in this respect that even where it grows it is never allowed to ripen on the plant. The several "hands" of which the bunch is composed ripen not simultaneously, but successively. and, as the process of ripening advances, the upper hands are much nearer to maturity than the lower hands on the same bunch. But, if the bunch be cut at the right moment—the choice of which is one of the most critical operations of banana-growing—the stalk retains sufficient sustenance and vitality to carry on the process of ripening to its maturity. The bunch is accordingly cut while the fingers are still green, the state of maturity at which it is cut being determined by the time at which the fruit is required for consumption. Thus bananas which are to be consumed on the spot are allowed to ripen much more fully on the plant than those which are to be consumed in the United States, and these again are more fully ripened than those which are to be consumed in England. But in all cases the final ripening takes place after the bunch is severed from the plant. Unlike the orange. the banana is, for this reason, just as good when eaten in good condition thousands of miles from the place where it grew as it is when eaten on the spot. In Jamaica it may take a day to ripen, in the United States it has required at least a week, in England at least a fortnight, but that is all. A ripe banana in England is just as good as a ripe banana in Jamaica, and both are ripened off the plant.

MODES OF PACKING.

This being so, the first problem to be solved was, as I have said, whether the ripening process could be prolonged for a fortnight or more. The United Fruit Company had long shown that it could be prolonged for a week or more, and had also ascertained that for a period of that duration the bunches could be shipped without packing and preserved in good condition without special appliances for refrigeration. So far bananas imported into England from the Canaries have been wrapped in cotton wool and packed in crates, each bunch in a separate crate. This is because the conditions of transport and delivery on board are not favourable in the Canaries to the handling of the fruit without injury, though, where the conditions are more favourable, as they are in Jamaica, it is found that the bunches can be safely stowed and carried on board without packing of any kind. They are simply placed one above another and one against another in large receptacles in the fruit chamber. Their preservation in these conditions is a matter of ventilation and regulation of the temperature. The United Fruit Company, having a shorter transit, do not employ special appliances for this purpose, but in the steamers of the Direct Service the appliances for ventilation and the

regulation of temperature are very complete, and, apparently, entirely successful in the result. It is now certain that the banana can be brought in good condition from Jamaica to England, and that the ripening process can be safely prolonged over the 14 days or more occupied in transit from field to market without injury to the fruit. This at least may be taken as proved by the first experiences of the Direct Service. It remained for further experiences to show that the fruit could be cut at the right moment in Jamaica and sold at the right moment in England. It was quite in accord with the precedents of the Canary banana trade that this problem should present some difficulties. It was not less in accord with the same precedents that the difficulties should be surmounted in time. I think it may be taken for granted that the complete solution of the problem is now assured, if not already accomplished. The promoters of the Direct Service are not the men to enlarge their undertaking on a precarious or merely speculative basis. They are now taking preliminary measures for the establishment at no distant date of a weekly, instead of a fortnightly, service.

THE CANARY BANANA TRADE.

It follows, then, that the trade in bananas and, indeed, in many kinds of tropical fruit between Jamaica and England is capable of immense development. The supply is practically inexhaustible; all that is needed is a corresponding demand. Of the growth of this there seems to be very little doubt. The trade in bananas from the Canaries is quite a recent creation. It began in a very modest and tentative fashion, just as the American trade with Jamaica began. It now employs something like 25 steamers a month. But the supply from the Canaries is not inexhaustible, and the Jamaica banana is both larger and cheaper to buy. It is true that the transport of the Jamaica banana is more costly, owing to the much greater distance to be traversed between field and market, but this, again, is largely balanced by the cost of packing the Canary banana for transit, involving more labour and an unremunerative export of the materials for packing from England. Hence, if the trade in Canary bananas has grown to the dimensions indicated above in a few years, it is not hazardous to assume that there is abundance of room in the English market for the Jamaica banana also.

PLANTAINS V. BANANAS.

Let me here state quite plainly that the Jamaica banana is not a plantain, as has been alleged to its disadvantage. Such an allegation can hardly be made in good faith by any one who knows what he is talking about. It rests on a confusion of nomenclature. There are two distinct edible products derived from two closely allied varieties of the *Musa*. One is eaten raw as a fruit, and this is universally known in the West Indies as the banana. The other is eaten cooked as a vegetable, and is known in the West Indies as a plantain. In the East Indies, on the other hand, this distinction is not observed

in common parlance, the banana proper of the West Indies being often called a plantain in the East. Now the banana imported into this country from Jamaica is a banana proper in the West Indian sense. It is just as much a banana as the Canary banana, and is, as a fruit, intrinsically quite as good as, if not better than, the Canary banana, which is a smaller fruit, obtained from a plant of lower growth, originally derived from China. This variety is not very highly esteemed in the West Indies where the standard banana of commerce is the fruit known and highly appreciated throughout the United States as the Jamaica banana. This latter is no more a plantain in the West Indian sense than it is a potato. In the East Indian sense, on the other hand, the Canary banana is just as much a plantain as the Jamaica banana is. That is the true history of a mystification which appears to have done not a little to prejudice the Jamaica banana in this country.

THE UNITED FRUIT COMPANY.

It is true that the banana, whether of the Canary or of the Jamaica variety, is not to the taste of every one. Many people find it insipid, some few find it indigestible. But experience shows that the appetite for it grows by what it feeds on, and grows apparently without limit. The story of the Boston Fruit Company, now the United Fruit Company, has often been told. Its founder, who is still alive and still the head of the company, was the captain of a New England trading schooner who some five and twenty years ago shipped a few bunches of bananas in Jamaica at a venture, buying them from negro settlers. The company now has a capital of 20 million dollars; it owns large estates in Jamaica, in Cuba, in Puerto-rico, and Costa Rica: its shares stand, I am told, at 100 per cent. premium: and it ships annually over 20 million bunches of bananas to the United States, more than a third of which are grown in Jamaica. Yet, as I pointed out in *The Times* of December 29, 1899, the area of land in Jamaica actually under banana cultivation was in 1896 less than 20,000 acres. In the *Handbook of Jamaica* for 1901, it is given as over 25,000 acres for 1899, so that in three years it had increased by more than 25 per cent., while the area under sugar-cane had decreased in the same period from over 30,000 acres to a little more than 26,000, or by over 13 per cent.

POSSIBLE OUTPUT OF JAMAICA BANANAS.

These figures are significant of the large changes now taking place, for good or for evil, in the agricultural and industrial economy of Jamaica. It is to be hoped, for many and cogent reasons, that the decline of the sugar cultivation has now reached its limit. Be this as it may, it is certain that the development of the banana cultivation, and of other fruit cultivations associated with it after the manner explained in the letter above referred to, is not even yet within measurable distance of its limit. Jamaica contains over 4,000 square miles in all. Of these some 3,670 square

miles, or 2,318,800 acres, lie at an elevation not exceeding 2,000 ft. above the sea that is, at an elevation favourable to the cultivation of bananas if other conditions are suitable. It is a very moderate estimate to assume that, of this latter acreage, at least $2\frac{1}{2}$ per cent. is available at the same time for the profitable cultivation of bananas for export, and this would leave a large margin for the periodical transfer of the cultivation to new soil at the end of five years or so. In other words, it is possible for 58,000 acres, at the very lowest estimate to be under cultivation in bananas at the same time. As the export of bananas is already some eight or nine millions off 25,000 acres, it follows that an export of 20,000,000 bunches at least is possible off 58,000 acres. I am therefore fully justified in saying that the supply is practically inexhaustible.

DEMAND FOR BANANAS.

But will the demand be equal to it? That remains to be seen. I can only point to the amazing growth of the Canary banana trade in England and of the Jamaica banana trade in the United States, associated, as the latter is under the United Fruit Company, with a still larger growth in Costa Rica and a growing cultivation in Cuba and Puertorico. This latter is an element by no means to be overlooked. The time may come when the United States will no longer look to Jamaica for bananas, and, looking to Cuba and Puertorico, may even exclude the Jamaica fruit, in the interest of planters in the American Antilles. That time is not perhaps at hand, but if ever it comes it will bring disaster to Jamaica, unless in the meanwhile she has provided herself with another string to her bow. The string is now twisted and fitted for, in spite of Froude, the sons of England are still willing to try and bend the bow of Ulysses on occasion—but it is rather a puny string at present. The contract for the Direct Service only provides for a fortnightly steamer carrying 20,000 bunches of bananas. This amounts only to half-a-million bunches annually, a mere drop in the ocean compared with what Jamaica can supply in the future, and does supply at present to the United Fruit Company. But the contract does not exhaust the possibilities of the trade, and the service is already destined to become a weekly one. That will account for a million bunches a year, but even that is no very large demand as judged by the consumption of the United States, and no very large supply as judged by the capacity of Jamaica to produce. At the height of the banana season—that is, at the time of the year when fresh fruit is not otherwise to be had in the United States—from 18 to 20 steamers a week laden chiefly with bananas leave Jamaica for some port or other of the United States. It seems visionary to conjecture that the fruit trade with the United Kingdom will ever approach to anything like the same dimensions, but more unlikely things have happened, and a generation ago any one who predicted the growth of the Canary banana trade to its present proportions would have been regarded as equally visionary. Its founder was long thought a fool for his pains. He is also the founder of the Jamaica banana trade.

BANANA CULTIVATION.

Moreover, though the banana is and must always be the mainstay of the Jamaica fruit trade, there are many other fruits which can be cultivated to a profit for export. Some high authorities think that the cocoa-nut is quite as profitable a cultivation as the banana, though, as it only comes into bearing after about seven years, the returns are not so rapid. On the other hand, it remains in bearing for a hundred years or more and requires little or no attention. The banana will only grow to perfection on the same soil for about five years consecutively. The stem dies down annually after producing its fruit, but the root is perennial and produces suckers, one of which is allowed to take the place of its predecessor on the same spot. At the end of five years the land requires deep ploughing to work in the decaying matter left by the previous crops, and new stocks are planted, often on fresh ground. But an abandoned banana plantation need not be left fallow. During its occupation by the banana the luxuriant growth of the latter affords the required shade for other and more permanent forms of cultivation, such as cacao, coffee, nutmegs, limes, oranges, and cocoa-nuts, so that when the time comes for giving the land a rest from the banana it is stocked with permanent fruit trees, just coming into bearing. Many of these cultivations are less profitable than that of the banana, but they are more permanent and much less precarious.

RISKS OF BANANA CULTIVATION.

Banana-growing is undoubtedly a very risky business. Its profits are great when realized, but a violent north wind, such as occasionally blows in Jamaica, may destroy the whole growth of a year in a single night. There is no guarding against these "blows," as they are called, and no anticipating them. The planter must take his chance. The wind bloweth where and when it listeth, and it may ruin one planter's crop and leave that of another unscathed. It would naturally seem that this is a case for insurance, but I am told the risk is too great. I should rather conjecture that the enterprise and capital of Jamaica are too timid. It hardly seems likely that the United Fruit Company could thrive so well as it does on a business of which the risks are so great as to be incapable of insurance. The company grows a considerable proportion of its own bananas, and presumably finds it profitable to do so, underwriting its own risks. It does not seem clear why other planters should not seek to cover their risks by suitable methods of insurance. But apparently they do not.

RETURNS ON BANANA CULTIVATION.

On the other hand, the profits when realized are very great. Good agricultural land may be bought in Jamaica for from £5 to £10 an acre. For agricultural purposes the very best land rarely sells for £20. The following is a statement made by an experienced planter of the cost and yield of banana cultivation on a favoured site and soil in the parish of Portland that is,

in the district most favourably situated for the sale of the bananas to the United Fruit Company. It is given by Mr. Henry Cork, a well-known planter, in a little "Handbook of information for intending settlers and others," entitled *Jamaica in 1897*. Mr. Cork explains that "these figures represent about the very best results obtained on about the best cultivated land. . . under most favourable circumstances." It will be seen that they leave a considerable margin of profit for circumstances much less favourable.

Stalks per acre, 330			
Gross sales per acre .	£27.	1.	3.
Cost of cultivation and delivery per acre	6.	18.	6.
Net profit	£20.	2.	9.
Selling price per stalk		1.	7½
Cost per stalk cultivation and delivery			5¼
Net profit per stalk		1.	2¼

The figures include the cost of keeping up a herd of cattle, cleaning and fencing pastures, watchmen, herdsmen, salaries, general supplies, and all minor improvements. The distance from shipping place is one mile on a level road.

Mr. Cork adds:- "Each acre was weeded, ploughed, and harrowed seven times during the year; forked around the roots once in the year; suckered regularly whenever the suckers showed. Forty acres of the cultivation have been bearing since 1880 and are still (1896-97) in cultivation. The crop in 1887-88 averaged ten six-hands to one nine-hand. The crop for 1892-93 averaged 15 whole bunches to one six-hand. This has been done without the aid of manure, and shows the result obtained by improved methods of cultivation." Similar information derived from the same source is given in the *Kew Bulletin* for 1894, in an exhaustive and most instructive article on the banana, its varieties, and its cultivation. Land which can yield such a return as this should surely be able to bear a high premium for insurance and yet leave an average of profit sufficient to make the British farmer's mouth water. Even if the net profit were only half as much, it is realised in a year or 15 months at the outside from the time of planting, and would seem to be capable of paying the whole of the original cost of the land at the average price of land in Jamaica.

OTHER JAMAICA FRUITS.

Yet, though the banana, both on account of its extraordinary fecundity and because of its capacity to afford shade in the earlier stages of more permanent cultivations, must always be the mainstay of the export fruit trade, there are other fruits in Jamaica well suited for the European market. Of these the orange is perhaps the chief, though the grape fruit, a misnamed fruit of the *Citrus* family, highly appreciated in the United States but little known as yet in Europe, may some day run it hard. The best oranges in Jamaica are as good as any in the world. They are exported already, chiefly to the United

States, to the extent of 100,000,000 annually, but the number that could be grown in the island is literally incalculable. The export trade to Europe hardly exists at present, and the Jamaica orange has never had justice done to it in England, because the supply has hitherto been irregular and precarious, and the specimens sent have too often been picked without due selection and very carelessly packed. But, when English people once make acquaintance with the Jamaica orange at its best, they will begin to understand Froude's saying, "The worst orange I ate in Jamaica was better than the best I ever ate in Europe." The pine-apple, again, can be grown to perfection in Jamaica, and there is no difficulty about its transport. It will not be long, perhaps, before Jamaica pine apples are sold in England for something like a shilling apiece. Then there is the mango, which should carry well for a fortnight or more, if picked at the proper stage of maturity and allowed to ripen, like the banana, under proper conditions of temperature and ventilation But there are mangos and mangos. The poorest are hardly worth eating, tough in texture and with a strong flavour of turpentine. The best are hard to beat, luscious, refreshing, wholesome, and exquisite in flavour. The mango was imported into Jamaica from the East Indies in 1782. Several specimens were brought, and the story goes that the plants were numbered, but that the description corresponding to the several numbers was lost on voyage. It was found that the plant numbered 11 produced the best fruit, and the best mangos in Jamaica are still known as "Number 11" The tree now grows everywhere throughout the island and is one of the most salient features of its characteristic verdure, but unfortunately it was not "Number 11" that thus populated the island, though that variety is fairly common and might be increased by cultivation. Another variety of equal repute is known as the "Governor.' It was, I believe, first imported at the instance of Sir John Peter Grant, who was Governor of Jamaica, after the disturbances of 1865. If mangos are to be brought from Jamaica to England, none but "Governors" and "Number 11's" should be imported. It would encourage a not ill-founded prejudice against the fruit if inferior specimens were allowed to find their way to market.

PROSPECTS OF THE TRADE.

It may be thought, perhaps, that I have exaggerated the prospects and promise of the Jamaica fruit trade. Time will show. There are those who think that the subsidy granted to the Direct Service would have been better expended in some form of encouragement to the sugar industry. This is too large a question to be discussed here. I am concerned rather with the accomplished fact of the subsidy to the fruit trade than with the very speculative and complicated problem of the sugar industry and its future, and I cannot doubt that, whatever may be the future of the sugar industry—I sincerely trust it may be a prosperous one --the future of the fruit trade is now assured so far as the opening of a new market in Europe can assure it, if the planters of Jamaica know how to make the best use of their opportunities.

ADVICE TO INTENDING CULTIVATORS.

This being so, the question will naturally be asked Can a young man of energy who commands a moderate capital, say from £500 to £2000, and is prepared to work hard, be recommended to go to Jamaica and embark his capital in tropical agriculture? There is only one answer to be given to this question, and it cannot be too widely known. No man should dream of engaging in agriculture in Jamaica on his own account without having first studied the situation carefully and cautiously on the spot. The climate may not suit him, the mode of life may not suit him, the nature of the occupation may not suit him—in a word, he may not, for one reason or another, be the right man to succeed. That he must determine for himself. Jamaica is no Eldorado, it is no place where a man can plant his capital in the ground and then sit down and wait for it to grow. Tropical agriculture is not a trade to be learnt in a day. It requires an apprenticeship, like any other, and the best thing for a young man to do who thinks it may suit him is to seek a subordinate situation on some plantation for a time and judge for himself how he likes the life and what he thinks of its prospects. Such situations are not difficult to obtain by those who go the right way to work—Messrs. Elder, Dempster, and Co. are, as has been stated in *The Times*, prepared to assist applicants in obtaining them - and a young man who takes one will very soon find, or be told, whether he is likely to succeed.

NECESSITY FOR EXPERIENCE.

But I repeat with all the emphasis I can command that a young man who goes to Jamaica without experience and without training, possibly with little aptitude for hard work of any kind, and with none at all for hard work in the tropics, and expects to turn his capital into a fortune in a few years, had much better stay at home. He will very quickly be undeceived and disappointed, and then, instead of blaming himself for an imprudent venture, he will most probably join the too numerous band of those who, having failed in the West Indies, insist that the West Indies and not themselves are to blame, and cry stinking fish for the rest of their lives. The question has more than once been put to myself, and I know it is constantly being put to others, "Am I likely to succeed in the West Indies?" I repeat that there is only one answer to be given with any regard to prudence and caution—It is "Go and see for yourself. Some succeed, many fail. Those who succeed are seldom able, and not often willing, to tell how much is due to their own aptitude for the work. Few who fail ever allow that it may possibly be their own fault."

The following letter which appeared in *The Times* of September 3, from the Imperial Commissioner of Agriculture for the West Indies affords additional information respecting the varieties of bananas cultivated in the West Indies and in the Canary Islands:

To the Editor of The Times.

Sir,—The very interesting account of the Jamaica fruit trade which appeared in *The Times* of Friday last is valuable not only for its accurate statement of fact, but also for the singularly clear and interesting manner in which the subject is presented for the information of your readers.

I have been associated with questions of an economic character connected with the West Indies for nearly a quarter of a century, and I have no hesitation in supporting your Special Correspondent in the view he has taken as to the intrinsic merit of the Jamaica banana, and to its being at least equal, if not superior, to the Canary banana. There are, as is well known, a great many varieties of bananas. In the *Kew Bulletin*, 1894, pp. 229-311, an account is given of about one hundred named varieties existing in various parts of the tropics. They are supposed to have had a primitive existence in tropical Asia, and to have been diffused at a period "contemporary with or even anterior to that of the human race." According to Oviedo, the edible bananas were introduced to San Domingo, soon after the discovery of the New World, from the Canaries. It is believed they did not previously exist in any of the eastern parts of the American continent.

THE JAMAICA BANANA.

The banana hitherto exported from Jamaica and so largely consumed in the United States and Canada is the best of the large bananas, and is highly esteemed by Europeans throughout the West Indies. It was at first cultivated at Jamaica under the name of *Martinique* banana; in Trinidad it is called *Gros Michel*, and in Dominica *La Rose*. It is now the established banana of commerce, and over twenty million bunches are annually imported into the United States and consumed as a dessert fruit.

There can be no question as to the Jamaica banana being a first-class fruit. It is large, attractive in colour, and bears transport better than any other sort. When at its best that is, gathered when fully developed and ripened slowly it rivals "in lusciousness and delicacy the most delicious pear." It is almost identical with the celebrated *Champa* and *Ram Kela* fruits of Bengal. It is probable that, so far, it has not reached this country in the best condition. That, however, is only a question of time.

BANANAS V. PLANTAINS.

Your Special Correspondent has very clearly pointed out that in the West Indies the banana (*Musa sapientum*) and the plantain (*M. sapientum*, var. *paradisiaca*) are closely allied but

distinct fruits. The former (or sweet plantain) is a dessert fruit, while the true plaintain is eaten cooked as a vegetable. In India and Ceylon both sorts are commonly known as plantains, but they are used differently, as in the West Indies.

THE CANARY BANANA.

The Canary banana is yielded by another species, originally from Southern China, hence called *Musa chinensis*. The plant is smaller than that yielding the Jamaica banana and it is often cultivated in this country under glass. The late E. W. Cook, R.A., grew it with great success even in London. It is commonly to be seen in fruit at Kew, Sion-house, and other gardens. In 1891 two plants were growing at Parkfield, near Worcester, "carrying clusters of fruit weighing between 80 and 100 pounds each." It is generally known in England as the Chinese or dwarf banana. It is well adapted for cultivation in the Canary Islands, for it is suited to sub-tropical conditions, is easily protected from strong winds, and thrives under irrigation. It is well known in tropical countries, but is not largely cultivated in the West Indies, probably because it is not so productive on a large scale as the Jamaica banana. It may be interesting to place on record that the introduction of the Chinese banana from the Chatsworth gardens into the Polynesian Islands by John Williams, the Martyr of Eromanga, put a stop to the famines that previously had devastated some of those islands. The Chinese banana was found to be much less affected by violent storms which caused considerable damage to the taller sorts.

"FIG BANANAS."

It has been often suggested that the delicate and luscious bananas known as "fig bananas" and "ladies fingers" should be introduced to this country. They are undoubtedly superior to the Jamaica and Canary bananas, but the skin is too tender to admit of their being handled for export purposes; besides, the bunches are so small that they would be acceptable only to a very small section of the community. These very choice and desirable fruits, which cannot be largely grown outside the tropics, will probably be unattainable elsewhere for some time. A correspondent in *The Times* of Saturday recommends the importation of the plantain as a possible new vegetable in this country. There would be no difficulty in growing plantains in any quantity in Jamaica, but it is doubtful whether they would suit European taste, and there is the possible difficulty with the cook. A fruit to be eaten raw is easily dealt with, but an unknown vegetable presents difficulties that would take years to overcome.

I am, Sir, yours, &c.,

D. MORRIS,

Imperial Commissioner of Agriculture
for the West Indies.

London, Sept. 2.

RICE GROWING IN BRITISH GUIANA.

In the Subsidiary Report attached to the Report of the West India Royal Commission of 1896 7. the following summary is given (pp 88. 89) respecting rice cultivation in British Guiana :

As the coolie immigrants constitute more than one-third of the population of British Guiana, rice is largely consumed in the Colony. The imports in 1895 96 were 10,262,831 lb. (about 22,000 tons), of the value of £183 391. There is a Customs duty on rice at the rate of 35 cents per 100lb., yielding a yearly revenue of about £30,000. Rice sells locally at 20 cents per gallon (8lb). Considering the favourable conditions that have always existed for the cultivation of rice in British Guiana, it is a matter of surprise that it has not already become an established industry.

As long as high prices ruled for sugar, possibly it was more profitable to grow sugar than rice. Under present circumstances there can be no doubt that the planters of British Guiana should follow the example of the cotton planters in the Southern United States, and during a period of great depression in their staple industry endeavour to produce most of the food stuffs, fodder, and other necessary articles on the spot. It is a suicidal policy to purchase such necessities in foreign markets with sugar at present prices. The suitability of the coast and river lands in British Guiana for growing rice is admitted on all sides. Professor Harrison states that the soil is as well suited for rice cultivation as for sugar. Further, the coolies, coming from the rice-growing districts of India, are well acquainted with the cultivation, and readily enter upon it. In the report of the Special Commission on Minor Industries it is stated : "The opinions expressed by those who have gained practical experience on the subject are unanimous as to rice being a product which is being, and can be, profitably grown in this Colony. The very large and general consumption of this article of food, the favourable condition under which it can be grown. and the excellent quality of the grain produced, fully justify the encouragement of the cultivation of this product, which it may be hoped, after supplying local wants, may in time form an item in this Colony's export list."

The evidence of Mr. A. R. Gilzean. who has an intimate knowledge of rice growing, embodies the experience of 11 years in the following words : "(1) There are several thousand acres in the Colony on the front lands of the estates with drainage and water supply available which can grow three crops of rice a year very profitably ; (2) There is always a good demand for creole rice at a higher price than imported rice : (3) the crops after the first one are large and wonderfully regular, being practically unaffected by the seasons ; (4) The cultivation of rice does not exhaust the land, so neither manuring nor resting have to be resorted to."

Mr. Bassell Winter, of Coffee Grove plantation, states: "For 10 years the coolies living on or near Coffee Grove have culti-

vated successfully over 100 acres of rice on this estate, and I think it might be grown nearly all over the Colony on the low-lying front lands." According to this witness the first cost of preparing the land by digging, levelling, &c., is somewhat heavy, and may amount to $16 to $24 per acre. This, once done, does not need to be renewed. The cost of planting, weeding, picking, threshing, and husking (including $8 for rent) amounts to $15.52 per crop. The average return per acre per crop is eight bags of cleaned rice. Five crops are produced in two years. The rice sells locally at about $6 per bag. This is calculated to yield a return of $48 per crop against an apparent expenditure of $15.52 per crop. This is exclusive of the first cost of preparing the land. Mr. Winter further states: "The immigrant population like the rice cultivation, and if they can obtain a small piece of land of their own on which to build a house with land suitable for rice cultivation within easy distance I think a good many would settle down in the Colony, thereby saving the cost of their return passage, besides which they would contribute to the general revenue. There are 250 coolies on this estate, and last financial year they took out licenses to the value of $315."

Mr. H. T. Perkins, the Acting Commissioner of Mines, in a memorandum submitted to the Royal Commission, states: "Rice is at present grown chiefly by the East Indian immigrants, who have acquired parcels of land in various localities, but there are not many of large area. A proper system of water supply and drainage and cultivation would be of immense advantage to the people, who are too poor to undertake large works of this kind themselves. The grain produced is full and well grown and furnishes a very nutritious food, being preferred by many coolies to the Indian grain. It sells in the paddy for $1.20 per bag, and is also a useful food for cattle and horses and pigs, and if it were more largely grown on the thousands of acres so well adapted for its cultivation, a large export trade might, in years to come, be built up by means of sufficient capital."

"The best rice lands are in the rear of the sugar estates and on the Mahaica, Mahaicony, and Abary creeks and coasts, the Barima and Waini rivers, and on the Corantyne coasts." The *Louisiana Planter*, after reviewing the circumstances of the coast lands in this Colony, remarks, "all this would indicate an ideal country for the culture of rice."

Mr. Andrew Hunter, in evidence before the Royal Commission, mentioned that "on Estates Bath and Adelphi three-fourths of the houses of the coolies are full of paddy rice grown by themselves. . . . . Some of them had as many as 25 bags." The Honourable A. Webber stated that "in the first instance there is a large field for rice cultivation to supply local consumption. . . . . That alone would tend to keep a million dollars in the Colony."

There can be no doubt as to the decided opinion which prevails that rice-growing is a most promising industry on the coast lands of British Guiana. The cultivation so far has been undertaken on comparatively small areas by coolies, and with

very crude appliances for threshing and husking the grain. Recently a loan has been sanctioned by Government for erecting and working one or more rice factories where the rice could be milled and prepared at a small cost for local consumption. The present cost of husking rice by hand-pounding in mortars is estimated at 3s. 6d. per bag. At well-equipped mills, this could be done at a cost of about 1s. 6d. per bag.

At the second West Indian Agricultural Conference held at Barbados in January 1900, the following general information was furnished respecting the cultivation of rice in the West Indies (*West Indian Bulletin* vol. I. pp. 280, 281): -

Rev. Dr. Morton (Agricultural Society, Trinidad): I had the pleasure some years ago of introducing rice cultivation into St. Lucia. It would be interesting to know what progress, if any, has been made in that direction. It might be interesting also, to know whether rice cultivation could not be introduced into some other parts of the West Indies.

Two principal kinds of rice are cultivated in Trinidad a rice which ripens in ten weeks, and another which takes five months. We have a small mill for husking, but some of the people husk their rice in a mortar according as they want it. I may mention that in some parts of Trinidad there were areas of swampy land which none would buy unless they were obliged to take them in their lot. Later on, however, East Indian coolies bought them, and some of these lands are now our most successful rice fields. At present large stretches of land eastward of Port-of-Spain are being established with rice cultivation.

Mr. G. S. Hudson (St. Lucia), in reply to the Rev. Dr. Morton: I can say that the rice cultivation has been continued in St. Lucia. but it is still confined to the East Indian coolies. As far as I can gather, there is no inclination on the part of the peasants in St. Lucia to take it up. There are about fifty acres under cultivation. The paddy is husked in mortars.

Mr W. Fawcett: In Jamaica several attempts have been made to extend the cultivation of rice in that island. Ten or eleven years ago a medical man in a western parish took great interest in it and erected a husking mill on his estate. Later, another planter in the same district took it up very energetically. We import seed rice of the best varieties for him from Calcutta. Another planter on the other side of the island, where there are extensive swamps, is doing the same thing. At present the industry is in an experimental stage. I believe that very soon a large amount of swampy land in Jamaica will be devoted to rice cultivation.

Mr. J. J. Quelch (British Guiana): The experience so far in rice production in British Guiana has been an unfortunate one. Rice has, and is being largely grown in the Colony but a factory erected for husking and cleaning rice in Georgetown has failed, probably, through mismanagement and the fact that the mill was not placed in a convenient and suitable

position. Thousands of acres of land have been placed under rice cultivation and many East Indians, who have land of their own, practically support themselves by the rice they grow. There are extensive tracts all over the Colony which could be devoted to rice cultivation.

In order to bring the subject of rice growing again into notice in these Colonies and furnish a brief statement in regard to previous efforts in this direction, at the request of the Imperial Commissioner of Agriculture for the West Indies, Mr. A. R. Gilzean who has long been identified with the subject has been good enough to prepare (in November 1900) the following sketch of the history of rice growing in British Guiana. This is by no means intended to be an exhaustive account, but it is published at the present juncture as a start for the dissemination of facts respecting rice cultivation in the West Indies, and with special reference to British Guiana:

On the lower part of the Essequibo Coast there is a belt of land, near the sea, which is on a lower level than that of the water in the navigation canals of the sugar estates. It is about twelve to fifteen hundred acres in extent and it lies on the front lands of all the estates. Previously to 1881 some desultory attempts were made to grow rice upon it. In 1881 a few hundred acres of it were under this crop. During the next ten or twelve years the industry did not develop rapidly, but it spread slowly all over the low lands of the Colony. The navigation canals of the Essequibo estates are supplied with fresh water from conservancies of the rainfall in lakes behind the estates. It is only in very long dry seasons that the supply of water is insufficient to flood the front lands at pleasure. Some of the estates find it inadvisable to encourage the growth of rice by the labourers and do not let the land which is suitable. Otherwise, all of this belt, so exceptionally favourable for rice cultivation, which is available is rented in lots of from a quarter of an acre to one acre by East Indian immigrants, and, lately in a few cases, by black people. One of the next places where the rice industry assumed any proportions was plantation Prospect in Berbice where about 150 acres were cultivated for several years although there was no water supply except from the clouds. Only two crops a year were grown and the rent charged for the land was very low. Failures of crops were frequent but the area of land in rice was maintained. Plantation 'Novar' in the Abary District is the property of a number of Coolie labourers. The water supply is very poor, but it has been cultivated for rice for some years and now every available acre of it is planted up twice a year. On a large sugar estate in Berbice (Port Mourant), Mr. Murray found it advisable to encourage the growth of rice by the labourers with a view to attaching them to the property. There is said to be 800 acres cultivated for rice there now. The water supply is good, but by no means perfect, and failures of crops have happened. I believe that the rents charged are only nominal.

The islands in the mouth of the Essequibo River have no

means of conserving water and were for some time considered unsuitable for the growth of rice. It has, however, been found that the river water is seldom salt and that the spring tides, which rise to a height of one to three feet above the general land level, provide an excellent supply of water for irrigation when the rainfall is not sufficient for the cultivation. The islands of Wakenaam and Leguan are at present the most flourishing rice districts in the Colony. The cost of preparing land there is generally very low as most of the river dams of the estates, formerly cultivated in sugar, had fallen into disrepair and for years the tides went in and out leaving deposits of mud which filled up the old drains and caused a growth of bush which killed out all the grasses and weeds. This land has only to be cleared of the bush, by means of cutting and burning, and is then ready for the reception of rice plants without any further preparation. It is seldom that any weeding has to be done to it for the first crop, which is generally regular and heavy.

Although special mention has been made of certain districts that have been more prominent in the history of the rice industry in its earlier stages, it may be said that rice cultivation is now general, to a greater or less extent, all over the low lying lands of the Colony. It made slow progress from 1881 until about four years ago when it began to expand considerably. Last year the seasons were exceptionally unfavourable and two crops were almost entirely destroyed, in spite of which much larger areas than ever are being planted up. So far, the industry has been carried on almost entirely by East Indian immigrants who use lands, in a few cases belonging to themselves but in most cases hired from owners of existing or abandoned sugar estates. The drainage is in most cases pretty good, but irrigation generally is very imperfect and nearly all of the lands relied upon for crops would be described in America as 'providence rice farms.'

During the 'eighties' Carolina rice was the variety mostly grown. On the front lands of the Essequibo estates the crops averaged about 20 bags of paddy[1] to the acre. The plants came to maturity in 90 to 100 days after transplanting. No attention had to be paid to seasons as the supply of water for irrigation and the means of drainage were very good. It was by no means the exception for the same land to give three crops in a year. The principal drawbacks to the cultivation of this land were the cost of levelling, which necessitated filling in old open drains, the high rents which were asked, and the uncertainty of the first crops. Levelling the land cost from $15 to $24 an acre. The rents, including water for irrigation, ranged from $8 to $24 an acre per annum. First crops seemed particularly susceptible to attacks by a sort of plant bug which will be referred to later, and the crops on the sites of the old drains were usually so heavy that they lodged so badly as to be almost useless. These drawbacks were keenly felt by poor labourers, but still the industry slowly expanded.

A few years ago the growers began to find out that a varie-

[1] Paddy is the thrashed but unhusked rice. One bag of paddy weighs 120 lb.

ty called 'Berbice rice' gives very large returns although it takes a longer time to mature than the Carolina rice. I have been supplied with information, which is considered reliable, that crops have been reaped from the first planting of abandoned land on Wakenaam and elsewhere amounting to as much as 45 bags (5,400 lb.) of paddy to the acre. Other plantings than the first are reported to give from 25 to 10 bags in an average season. The variety is supposed to take five months to mature, but my observation, during the last few months, leads me to think that four months or less is sufficient, when the season is favourable. There are few recorded experiments of the returns of rice from land in the Colony, and the time it takes to mature; so the following table supplied by me to the the Royal Agricultural and Commercial Society of British Guiana in 1892 as the result of a trial of varieties of Indian rice may be interesting: -

Names of Samples.	Return per acre in one crop.		Number of days growth from transplanting to reaping.	Pounds weight of Paddy grown from one lb. of seed.
	Straw, pounds.	Clean rice, pounds.		
Ramsah ...	13,200	2,772	125	261
Musloti .	8,005	2,717	114	225
Orah Mettah ...	12,269	3,777	136	317
Bhojna ...	8,906	1,916	115	169
Sonad Hobay. .	5,726	2,221	112	272
Borad Hobay...	12,097	2,229	113	256
Connich Choor	9,261	1,417	136	170*
Creole	8,197	1,652	97	–

* Some stolen, so that this return is not accurate.

The variety of Carolina rice grown in the Colony and described as Creole rice in the table above is of a quality very superior to any of the ordinary Indian rices, and is valued in the English market at about the same price as Patna and Java rice. The so-called 'Berbice rice' is of even better quality, the grain being long, opalescent, hard and of a good size. The discovery of this prolific variety seems to have given a great impetus to rice cultivation in the Colony.

In some cases rice is sown broadcast, but as a rule it is grown in nurseries until the plants are about six inches in length, when they are transplanted. The cost of transplanting is about \$4.00 an acre. This system has a good many advantages, among which is the regularity in establishing a crop, and where rainy seasons are depended upon for providing water, the time gained by sowing before the rains set in. Nurseries require very little water and they need not necessarily be close to where the plants are to be grown when transplanted.

After fields are planted up they, as a rule, require very

little weeding. In most cases they require none whatever and the only attention that is necessary, until the grain ripens, is the regulation of the water supply. When very small areas are planted in one district, rice birds give a great deal of trouble but with large areas their depredations are so insignificant that nothing need be spent in driving them away. Reaping is generally done by women and children who pick off the heads of grain, leaving the straw standing. The usual price for the work is 12 cents per bag of heads. Two bags of heads, when threshed, give one bag of paddy. Sometimes the straw is cut with the grain. In either case the threshing is done in a very primitive fashion but at a small cost.

Ratoon crops are very seldom taken, as the yield is small and the quality of the rice inferior. Rice cleaning is done by pounding in mortars and the cost of turning two bags of paddy (210lb) into one bag of cleaned rice (165lb) is about 40 cents, and in some cases less. An Engleborg huller is used in Essequibo. It does good work, but the owner has not had sufficient experience of cleaning rice with it yet to give any figures with regard to the cost. A large rice mill was erected in Georgetown by a company some time ago. The company was unsuccessful and the mill fell into the hands of the Government who had advanced enough money to complete its erection when the company's funds were exhausted, but who would not advance a further sum which was required to make some slight alterations and provide funds for the purchase of paddy, etc., to give it a fair trial. Messrs. Wieting and Richter, a firm of Georgetown merchants, have now leased the mill and they may be depended upon to make it a success if it is possible to do so.

The growing of rice has been carried on, so far, almost entirely in small lots not exceeding an acre each. Advantage has been taken of any existing means of irrigation and drainage, but there has been no combination among the growers to provide themselves with any. It would be almost impossible for them to do so as the nature of the country necessitates that such operations be carried out on a large scale. No water is raised by pumping for the special purpose of growing rice. Practically no modern implements are used for cultivating the land, or for reaping, threshing, or milling. Considering the success of the industry under these circumstances there seems to be very great possibilities for it with a proper system of irrigation and the use of modern implements. Beyond a fatherly interest taken in their concerns by men like Mr. Murray, the rice growers have had no assistance in the selection of good varieties of seed, or by experiments in planting at different seasons or in any other way. Some planters look with disfavour on rice growing as it interferes with their supply of labour, and they naturally discourage it. The new Board of Agriculture, which is to be established soon, will no doubt supply the guidance which is necessary. To show what is done by a State Department in America for the rice growers there, who are men of a class very much better qualified to rely upon themselves than the poor Demerara Coolie, I quote from Bulletin No. 22 of the U.S. Department of Agriculture, Division of Botany, 1899: 'In 1880 a

peculiar prairie region was opened up. In 1884 enterprising settlers began the development of rice culture, by which, as now perfected, the elevated and normally or periodically dry prairie lands are flooded by a system of pumps, canals, and dykes, and when the rice is about to mature the water is drained off, leaving the land dry enough for the use of reaping machines. Under this system the cost of harvesting has been greatly reduced and the industry has undergone a rapid development. In 1896 the depressing effects of a new difficulty began to be felt. The varieties of rice most productive and otherwise satisfactory from a cultural standpoint, under the new system, were defective commercially, because the percentage of grains broken in the process of milling was very large, and the proportion of head rice made up of unbroken grains was low. The difference in wholesale price between head rice and broken rice is about 2c. per pound. When the broken rice ran up to 10, 60, or even 90 per cent. the whole industry was menaced. On the 1st July, 1898, an appropriation for the introduction of valuable seeds and plants from foreign countries, asked for by the Secretary of Agriculture in his estimates of the preceding year, became available, and on September 1st 1898, Dr. A. Knapp, of Louisiana, was appointed by the Secretary as an Agricultural Explorer, with instructions to visit Japan, investigate the rices of that country and purchase a stock suited to meet the requirements of the American problem. Dr. Knapp returned in the early spring of 1899 with 10 tons of Kiushu rice, which was distributed to experimenters . ..The results of the milling tests are now awaited.' I may mention incidentally that the results were favourable. The Louisiana rice growers now consider the Kiushu and a variety known as 'Honduras rice' as being the best kinds for them to cultivate. Seeds of these varieties have been ordered and a bag of each is expected to arrive in Demerara shortly.

Obstacles encountered in growing rice in British Guiana are very few as compared with those which have to be contended with in other countries. In Louisiana the cost of water for irrigation may be put down at about $6 an acre for one crop. There is no doubt whatever that perfect irrigation could be obtained in Demerara by pumping for a great deal less money. Dr. Knapp remarks in the Bulletin quoted above: 'In all delta rice lands, the rapid increase of injurious grasses becomes a serious question'; and again 'Frequent allusion has been made to red rice. The presence of any red grains in milled rice lowers the grade and reduces the price. The history of field cultivation has been that if red rice once obtains a foothold in a field, it increases rapidly from year to year until its presence in the paddy causes a reduction in the price of the rice. Finally it may prevail to such an extent that the rice becomes unsaleable. The land must be cultivated in some other crop for two or three years until the red rice is entirely eradicated. The loss to the rice planters from red rice in the crop has been great.' In Demerara neither weeds nor red rice give the planters any trouble. On the other hand some damage has been done to our rice fields by insects which Mr. Quelch clas-

sifies as 'forms of a species of *Penbastoma*, a genus of plant bugs closely related to the northern "chinch bugs" that do so much damage to wheat and corn crops.' Rice growers who supplied me with the specimens submitted to Mr. Quelch assert that they only attack rice planted out of season when it is forming grain. This should form the subject of investigation. Complaints have been made that the Colony grown rice does not keep so well as the imported article. This is a difficulty which should be overcome by experience in curing the paddy before milling.

The limits of this article only allow of my alluding briefly to the benefits which might result from the use of implements in the industry. By the use of drills the cost of sowing would be greatly reduced. On land provided with proper means of drainage, reaping machines could be used, which would reduce the cost of production by about 20 per cent, and greatly reduce the number of hands employed on a farm. There will be some difficulty in reaping 'Berbice rice' by machines, owing to the crops being generally so good that the ears are too heavy for the straw, causing the crop to lie as it ripens. As it, however, lies evenly and with no excess of straw it may be dealt with by certain kinds of reaping machines. Threshing machines will, of course, be adopted as soon as the crops assume sufficient proportions. Ploughing the land to get rid of the roots of an old crop and to prepare for a new one, may be left for some time to come to the Coolie and his primitive ox plough. The other day I saw a Coolie ploughing a rice bed which was covered with four inches of water. His plough was made by himself out of the crooked limb of a tree. It was worth about 3s. and he could carry it on his shoulder. In ploughing it was drawn by two splendid fat oxen, fed upon nothing but rice straw and a little grass which they picked up by the road side. The work done by the team was half an acre a day ploughed twice, in different directions. The total cost of cross ploughing an acre did not exceed two shillings.

Without going into details of the cost of production it can be confidently stated that the people can produce paddy, at a profit under present circumstances, at one cent per pound, delivered in Georgetown.

The production of rice is increasing rapidly in Louisiana. In the Bulletin No. 61 (second series) of the Agricultural Experiment Station of the Louisiana State University and A. and M. College, Dr. Stubbs says that 'there are now nearly four hundred miles of canals already constructed, irrigating about 225.000 acres of rice' in that State. 'These canals,' he writes, 'are kept full by enormous pumping plants from the streams flowing through this section.' The cost of the machinery and canals seems to average about $10.00 for each acre of land irrigated. The water has to be raised, in most cases, from 12 to 26 feet. A man's labour costs about $1.00 a day. Only one crop is obtained a year. The average yield is about 1,600 lb. of paddy per acre. Weeds and red rice give a great deal of trouble.

In British Guiana there are thousands of acres of virgin soil, near fresh water streams, eminently suited for rice

growing. The land is perfectly level and in no case would the water have to be raised more than 6 feet to flood it. Men can be got to work for 32 cents a day. The average yield is between 2,000 and 3,000 lb. of paddy per acre and as many as three crops can be taken in a year. No rotation of crops is required. The same land in some cases has been constantly cultivated in rice for twenty years without the use of fertilisers and with no perceptible falling off in the yield. No trouble is experienced with weeds or red rice. There is a higher duty on rice in America than there is in British Guiana, but there is very little doubt that the difference is more than counterbalanced by the more favourable conditions existing in the case of the latter country. If the rice industry flourishes in Louisiana it seems that it only requires capital, intelligently used, to make Demerara a successful competitor.

Owing to the kindness of Professor J. B. Harrison, C.M.G., we are enabled to give in the form of an appendix to Mr Gilzean's valuable paper the following table in which the annual returns concerning rice cultivation in British Guiana for the period 1897-1901 have been summarised. From this table it would appear that during the four years 1897-1901 there were produced in the Colony 16,717 tons of paddy (or unhusked rice) and 34,141 tons of clean rice. The value of the latter would be approximately £500,000.

RETURN SHOWING THE ACREAGE UNDER RICE CULTIVATION IN THE THREE COUNTIES OF BRITISH GUIANA, AND THE ANNUAL YIELD OF THE COLONY. 1897 1901.

Period.	Rainfall in inches.	Acreage under Rice Cultivation. Berbice.	Demerara.	Essequibo. Main-land.	Essequibo. Islands.	British Guiana total.	Yield of British Guiana. Paddy Tons.	Equal to Rice Tons.
1897—8	118·52	7,592	1,766	2,221	1,006	15,588	20,800	15,184
1898—9	49·93	4,612	1,520	...	293	6,177	6,371	4,653
1899—1900	52·70	978	2,175	1,150	816	5,419	4,001	3,603
1900—1	88·94	6,256	3,777	2,277	1,358	13,668	14,669	10,701

BEE-KEEPING IN THE WEST INDIES.

The Imperial Department of Agriculture has taken an active part in bringing bee-keeping under the notice of the people in the Lesser Antilles. In the first place it engaged the services of a competent Bee-expert to visit the several islands, to give addresses, to advise and assist bee-keepers and generally encourage right methods of treating the bees and obtaining honey of high quality.

The Expert engaged was Mr. W. K. Morrison, formerly connected with the United States Department of Agriculture. He visited the several islands in 1901 as follows: –

Barbados, January 1 to 21; Dominica, January 22 to February 5; Montserrat, February 6 to 20; Antigua, February 20 to 27; Grenada, March 16 to 23; St. Vincent, March 24 to April 12; St. Lucia, April 24 to May 10. After each visit a report on the condition and prospects of bee keeping was published locally in the *Official Gazette* and distributed for general information.

After a careful study of the circumstances Mr. Morrison is of opinion that the outlook for bee-keeping in the West Indies is very encouraging. At present, with the single exception of Jamaica,* a bee-keeping industry can hardly be said to exist. At Grenada, St. Vincent, Barbados and Antigua a few bee-keepers were met with, but in the other islands, as at St. Lucia and Dominica, with an abundance of honey-bearing flowers to be found all the year round, little or no attention had been devoted to bee-keeping.

At the conclusion of his tour Mr. Morrison prepared notes for a pamphlet which should give hints and suggestions exactly suited to the requirements of bee-keepers in the tropics. These notes, after careful revision by the officers of the Department, were issued in August 1901, as number nine of the Department's Pamphlet Series. The booklet, which is illustrated throughout, contains, in addition to the actual hints to beginners, lists of dealers in bee-keepers supplies, a glossary of technical terms, a provisional list of the principal bee-flowers of the West Indies, and other information of value to those about to take up the pursuit. This pamphlet has been widely distributed and can be obtained by all interested in bee-keeping from the local agents of the Department at four pence per copy.

It remains now to summarize briefly Mr. Morrison's reports on the present condition of the industry in the various islands, and its prospects for the future.

GRENADA.

A considerable number of bees are kept in the island, there being three fair sized apiaries as well as many on a smaller scale. There is considerable room for an extension of the industry, and no immediate prospect of overstocking the island with bees. The most desirable situation for apiaries would

* See 'Bee-keeping in Jamaica,' by J. Doidge, *West Indian Bulletin* vol. I. pp. 305 9.

appear to be about two miles from the coast so as to secure the fine logwood honey, which for quality is unsurpassed in the world.

Grenada abounds in honey-producing plants but Mr. Morrison recommends the introduction of two others, namely, the Cuban bell-flower (*Ipomœa sidaefolia*) and the 'raspberry' (*Rubus rosaefolius*): the latter i well adapted to cultivation in the high lands.

St. Vincent.

There are practically no apiaries as yet in St. Vincent but merely a few old-fashioned hives capable, however, with care of forming the nucleus of a thriving industry.

Many good honey-plants are to be found, in particular the raspberry and, in some of the Grenadines, logwood.

The high lands about Mesopotamia and the Souffriere are said to present very favourable conditions for bee-keeping.

St. Lucia.

In this island no one apparently keeps bees, such honey as is obtained locally, being procured by the very primitive method of felling trees and robbing the nests of wild bees. The absence of any bee-keepers is the more astonishing as the island abounds in good honey-producing plants, logwood being abundant and in one locality or another in bloom for a very long season. The local conditions are, on the whole, very favourable to the industry, but owing to the absence of domesticated bees it will be necessary for those who first take up the pursuit to import some swarms from Antigua or elsewhere. As an indication that Mr. Morrison's visit has awakened local interest, it may be mentioned that since his departure the St. Lucia Agricultural Society has voted £35 for the purchase of bee-keepers' outfits to be sold at cost price, on easy terms, to those desirous of engaging in the industry.

Barbados.

In Barbados a few apiaries exist, but none of large size. The majority of the bee-keepers reported small yields of honey, one reason for which, Mr. Morrison states, is insufficient care in shading the hives. By exposing the hives to the sun much injury is done and excessive swarming induced.

The honey produced is of two kinds: a dark honey largely obtained from the flowers of the mahogany tree so common throughout the island, and a light yellow honey, from the flowers of the sea-side grape (*Coccoloba uvifera*) abundant along the coast. The former is the better flavoured of the two, but the lighter colour of the latter would give it a more ready sale in any well-stocked market. Two races of bees are kept, *Apis mellifica* the common brownish-black bee of Northern Europe, and the recently introduced Italian bee. The latter is strongly recommended. Owing to the extensive cultivation of the sugar-cane Barbados suffers from a comparative scarcity of wild honey-producing plants. To help to remedy this the introduction of the Cuban bell flower is advocated on waste

lands. It seems improbable that bee-keeping will ever be an important industry in the island and the use of only comparatively small hives (American eight frame) is recommended.

DOMINICA.

One or two hives of bees exist in this island and these are of a very old-fashioned character. A certain amount of honey is obtained, as in St. Lucia, from the nests of wild bees.

Two kinds of bees were found, the brownish-black bee and a wild stingless bee, a species of *Trigona*. Bee-flowers are very abundant, and the best location for an apiary would appear to be at an elevation of about 1,000 feet and some three miles from the sea. Mr. Morrison is of opinion that the outlook for the industry in Dominica is excellent, and that the island could easily support 3,000 colonies of bees. He recommends that any additional bees required be imported from Antigua.

MONTSERRAT.

Two small apiaries were seen, but the hives were too small and insufficiently shaded. The races of bees present are the same as occur in Dominica, namely, *Apis mellifica* and the stingless *Trigona*.

Honey-plants are abundant, for instance logwood and limes, and the prospects of the industry seem good. In particular is bee keeping recommended as a profitable occupation for the peasantry, many of whom are very poor.

ANTIGUA.

The sole good apiary in the island is the one at the Botanic Station, consisting of twenty-five colonies. This apiary was started by Mr. A. G. Tillson the former Curator of the garden. Mr. Morrison remarks that it was in good condition, the hives been well shaded, properly spaced, and generally well arranged. In contrast to these he found the hives in common use, as a rule, too small and not well shaded.

The bees in domestication were the common brownish-black bee with a few Italian bees at the Botanic Station.

Honey-plants are plentiful and a good future seems before the industry in Antigua provided the bee-keepers keep in touch with the market and give careful attention to the methods of preparing, packing and shipping their produce so as to ensure its arrival in the best possible form. This can only be done by reading the current papers devoted to the subject. Extracted honey has a ready sale in the local market, and an extractor is obtainable on loan from the Botanic Station. Antigua honey which has been shipped to England has realized good prices, and there seems to be a good market for it.

Since the completion of Mr. Morrison's engagement considerable efforts have been made to encourage the industry by placing the means of obtaining hive appliances and information within easy reach of all interested. Model apiaries are being established in each island, either at the Botanic Station or at the Agricultural School, so that visitors can see the hives

recommended in actual working order and obtain practical information from the officers-in-charge who also are in a position to assist in obtaining hives, bees etc, at cost price. Queen bees can be obtained in the same way. In localities where bee-flowers are comparatively scarce, such as Barbados, packets of seeds of the bell-flower have been widely distributed free of charge. A great deal of interest has already been aroused in the subject and with every convenience at hand it is hoped that a flourishing industry may in time be established in these islands. This however will, in the end, depend largely on the care and attention which bee-keepers are prepared to give to the subject.

"THRIPS" ON CACAO IN GUADELOUPE.

Through the courtesy of Mr. Louis H. Aymè, United States Consul at Guadeloupe, a copy has been received of a translation of a report by M. Aug. Elot on the occurrence of 'thrips' on cacao in that island. This pest was the subject of an article, with figures of the young and mature insect, in the *West Indian Bulletin*, Vol. II. pp. 175-190, where its occurrence in Grenada, St. Vincent, St. Lucia and Dominica was noted, with a comprehensive description of its habits and distribution in Grenada.

M. Elot's report deals evidently with the same insect and, whilst showing that it has extended its range to Guadeloupe, describes an attack closely similar to that observed in some parts of Grenada during 1900. In his summary, M. Elot says that the pest is pretty widely distributed among the cacao plantations of Guadeloupe; that the damage is sometimes insignificant, sometimes very great, according to the environment; that the best way of protection against the disease is found in seeking favourable conditions for the culture and in giving the plantations every care compatible with such culture, and then if, in spite of these, damage is caused by the insects the remedy is to be sought in spraying the trees affected with kerosene emulsion.

The attacks of 'thrips' in Guadeloupe are similar to those elsewhere, the amount of the damage being large or small according to circumstances. Evidently M. Elot's experience fully confirms the view that whilst careful treatment of the trees will do much to lessen or avert the attacks of the pest, the ultimate reliance must be placed in spraying. The question of spraying was very fully dealt with in the article on thrips referred to above, and whilst kerosene emulsion was recommended especially for spraying pods, rosin and other washes were suggested for general treatment. The insect can probably be regarded as a pest of cacao always ready to become troublesome and cause damage whenever the conditions are favourable, either from drought or from neglect and wrong treatment of the trees.

Whether the pest will eventually become so destructive as to need extensive treatment on a large scale is doubtful, but cacao planters in Grenada, St. Vincent, St. Lucia, Dominica and Guadeloupe will need to be on their guard for signs of injury and use the spraying machine to check the increase of the insect whenever it becomes destructively abundant.

M. Elot's report states that the insect had been sent by him to Prof. Giard at Paris, who has named it *Physopus rubrocincta*. It was previously regarded here as belonging to the genus *Heliothrips*. Mr. Pergande of the U. S. Department of Agriculture, to whom the insect was referred for determination, was of opinion that it constituted a new genus allied to *Heliothrips*.

Specimens of the insect were also sent to Mr. E. E. Green, who had previously recorded the occurrence of a thrips on cacao in Ceylon. In a letter of September 16, 1901, he states:- 'I beg to acknowledge receipt of your specimens of the "Grenada thrips." This insect appears to be closely allied to the thrips affecting cacao in Ceylon The larva and nymph of our Ceylonese insect are also distinguished by a transverse crimson band, which appears to be a striking feature in the early stages of the Grenada thrips.'

The geographical distribution, as known at present, is Grenada, St. Vincent, St. Lucia, Dominica, Guadeloupe and possibly Ceylon. It is not improbable that the insect will be found to occur in other parts of the West Indies and South America.

THE "WITCH BROOM" DISEASE ON CACAO IN SURINAM.

In the course of a recent paper by Mr. A Howard, Mycologist to the Imperial Department of Agriculture, on 'The fungoid diseases of cacao in the West Indies' (*West Indian Bulletin*, Vol. II, pp. 190-211) attention was drawn to a disease which attacks cacao in Surinam, producing 'witch brooms'—as the curious bunches of malformed twigs are termed in the affected trees. The desirability of excluding this disease from the British West Indian Colonies in which the cultivation of cacao is an important industry was also pointed out.

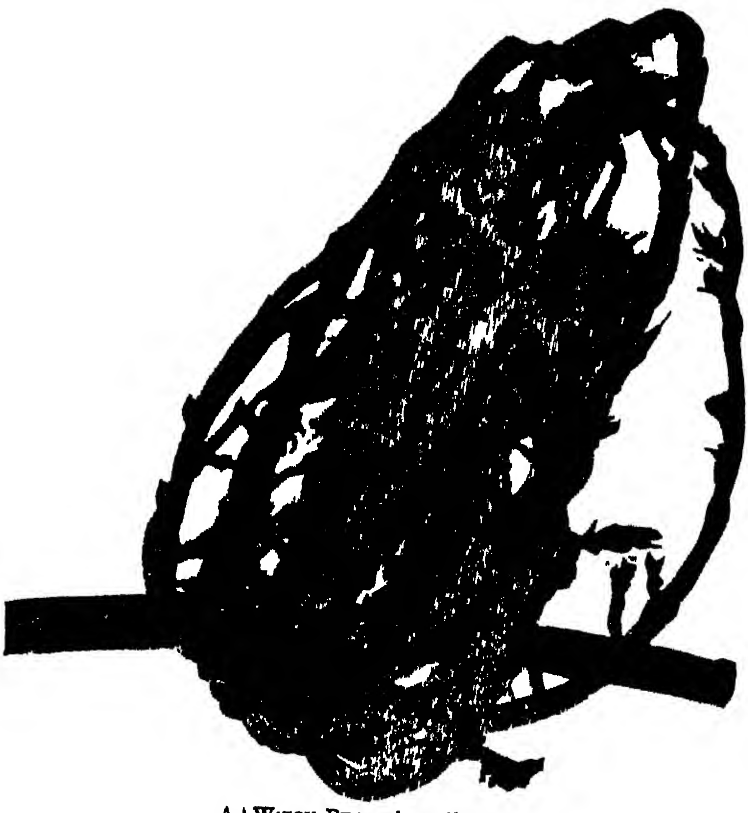
Since that paper was written the disease has been studied on the spot (between July and November of the present year) by Professor F. A. F. C. Went of the University of Utrecht, who has since visited Barbados and very kindly placed the results of his investigations at the disposal of the Department. Mr. James Mavor, of Marienburg plantation, Surinam, has also been so good as to forward a large quantity of diseased material, preserved in alcohol, to the Department which has been examined by Mr. Howard. As Professor Went's researches indicate that the disease is more serious than was originally

supposed, it is very desirable that the fuller information now to hand be placed on record for the information of cacao planters in the West Indies.

As mentioned in the paper referred to, the disease was first investigated by Professor Ritzema Bos, of Amsterdam, who discovered asci, or fruiting organs, of the *Exoascus* type on the under side of two of the rudimentary leaves borne on the twigs of the 'witch brooms.' The full account of his work is given in the *Tijdschrift voor Plantenziekten* for 1900, whilst shorter notices occur in the *Zeitschrift fur Pflanzen krankheiten* for 1901, p. 26, and the *Journal d'Agriculture tropicale*, September 1901, p. 72.

On account of the discovery of these particular fruiting organs, and the general appearance and internal structure of the 'witch brooms,' Professor Bos concluded that the disease was due to a new fungus, related to those known to produce, 'witch brooms' in other trees, and which he named *Exoascus Theobromae*.

The accompanying illustration, reproduced from his paper, shows the general appearance of one of these 'witch brooms' on a cacao tree.



A 'Witch Broom' on Cacao.

The normal mother branch is seen running horizontally and bearing the tuft of abnormal twigs on which the rudimentary leaves can be distinguished. (After Professor Ritzema Bos.)

The examination of diseased material, which had been preserved in formalin, forwarded to the Department by Mr. J. H. Hart in February last failed to reveal the presence of the characteristic fruiting bodies of the *Exoascus*. Mr. Massee of Kew was likewise unable to detect them in specimens sent to him. The further supply of material sent to the Department by Mr. James Mayor, in May last, gave no better results as far these fruiting organs were concerned, although penetrated in all directions by the fine threads or hyphae of some fungus. (The full details of the results of these examinations have been previously given, *loc. cit.* pp 205 6.)

At this juncture the recent observations of Professor Went in Surinam are of interest He also is of opinion that the disease is due to a fungus, although the evidence is not yet sufficiently conclusive to determine definitely what fungus is the actual cause He has found that in cacao trees containing 'witch brooms' the pods are also attacked by a fungus which causes a swelling at the side, and finally gives rise to a hard, woody pod which is practically worthless. He considers it probable that the fungus causing 'witch brooms' is allied to that which produces the hard woody pods, but in neither case has he observed any formation of spores, nor have his cultures of the fungus occurring in the 'witch brooms' and the abnormal pods produced spores. The absence of these prevents the exact determination of the fungus for the present. In addition, our want of knowledge concerning the process of spore formation leaves us in doubt as to the method by which the fungus spreads a point of the first importance in the consideration and application of remedial and preventive measures. The planters in Surinam have already found it advisable to cut out the tufted masses of twigs as soon as observed. This method will probably be sufficient to keep the disease from making much headway for the present. If however it has to be carried on to a large extent the productiveness of the trees must be impaired.

It is evident that sufficient is already known concerning this disease to render it very desirable that the greatest care should be taken to prevent the 'witch broom' disease of Surinam obtaining a foothold in the West Indian Colonies, and to this end the importation of all cacao pods, seeds and plants from the South American continent into these islands should be absolutely prohibited.

METHODS FOR DESTROYING LAND CRABS.

Experiments have been recently carried out in the destruction of the small land crabs that infest many low-lying places in Barbados and other West Indian islands. The crab on which these were tried is the small red land crab, with a large purple blotch on the back, probably *Gecarcinus lateralis*.

The usual remedy is to lay a mixture of cornmeal and phosphorus in each crab hole. This is effective, plenty of dead

crabs being found outside their holes next day, but the treatment is somewhat costly and phosphorous is not pleasant to handle. It was hoped it might be possible to find a simpler and less costly method of treatment that would be effective on a large scale. A variety of poisons were tried, such as Paris green, corrosive sublimate, boracic acid and flowers of sulphur, each mixed with cornmeal with or without molasses. In addition, attempts were made to drive out the crabs with kerosene and water or whale oil soap, and also every blade of grass on which they might feed was sprayed with Paris green. These proved to be ineffectual, and finally two further methods which seemed more promising were selected for careful trial. These were, treatment with hot water and poisoning with arsenic. The hot water was poured down the holes until the crabs either came out or were killed. An interesting point noticed was that almost boiling water killed the crabs immediately or caused them to drop their legs as the water touched them, whilst water just bearable to the hand (110 F) killed them more slowly, their legs not dropping off at all. This fact is important, as it is more satisfactory when the crab walks out and can be seen to die or can be killed. Care was then taken to mix cold water with the hot till the right temperature was reached, when a little poured down the hole sent the crab scuttling out leaving no room for doubt as to his death. All the holes were then filled up and this treatment was evidently successful.

The second method tried was to poison them with a mixture of white arsenic, molasses and cornmeal. This gives no apparent results at first, but if the crab-holes are filled up two days after the application, many will not be re-opened, showing that the crabs died inside. Also, if the re-opened holes were again closed up later, it was found that still more crabs had died. The arsenic, though slow, is evidently effective and is probably specially valuable as crabs that eat their dead relatives would also perish—a result not always obtained with phosphorus poisoning. The results of arsenic are most evident some days after the first application and there is good evidence for believing that the arsenic may kill, not one batch only, but two or more successively. Granting the three treatments, hot water, arsenic and phosphorus to be all effective, which should be adopted?

On calculating comparative costs the following figures were obtained:—

(1) Hot water treatment: Cost of fuel and labour \$1.60.

(2) Poisoning with arsenic:

Cost of materials at local prices 43 cents and labour 16 cents, total 59 cents; or with cost of material imported direct, free of duty, 19 cents, total 35 cents.

(3) Poisoning with phosphorus

Cost of material at local price 96 cents, and labour 16 cents, total \$1.12; or reckoning at direct import price free of duty, total 66 cents.

These figures were obtained from treatment of badly infest-

ed pieces of ground of equal size, and they represent as closely as possible equivalent values.

On comparing these figures it will be seen that hot water is too costly. Arsenic is less expensive treatment than phosphorus and deserves a trial on this account alone. In the preparation of the poison arsenic is also more convenient.

The proportions used were arsenic one ounce, molasses two ounces, and cornmeal one pound; these were simply mixed well together into a paste.

The preparation of phosphorus poison is thus described by Mr. G. E. Clarke of Graeme Hall, Barbados: 'I find the most economical way of destroying crabs is to poison them with a mixture of cornmeal and phosphorus mixed in the following proportions: 1 stick of phosphorus, 1½ inches long, four pints of cornmeal. Put the stick of phosphorus into a vessel and dissolve it into about four pints of boiling water; then add the meal, stirring all the time. Apply a very small portion of the mixture (at the top of each crab hole) either plain or folded up in a sweet potato leaf.'

These experiments, while showing that poisoning with stick-phosphorus is effective, point to a possible cheaper method. In treating crabs on a large scale the arsenic might be given a trial in comparison with the phosphorus with a view to obtaining a simpler and less costly field treatment.

RECENT EXPERIMENTS WITH SWEET POTATOS.

Sweet potatos (the enlarged roots of *Ipomea Batatas*) are among the most important agricultural products of the West Indies. As Mr. F. Watts *West Indian Bulletin*, Vol. I. p. 271 states: 'So far as the sugar-producing islands are concerned the sweet potato occupies the foremost place in the list of home-grown foods and is, probably, next to the sugar-cane, the most important crop grown. . . At present the crop is grown upon the sugar estates as a snatch crop and fulfils a useful purpose; owing to the short time it takes to come to maturity it can be planted after the (ratoon) canes have been cut when the potato crop will be ready for reaping from about December to February. After the crop has been reaped the land may be quickly prepared for a crop of sugar-cane. As the potatos usually meet with a ready sale the crop is of value to the sugar planter and acceptable to the labourer. Sweet potatos are largely grown by the peasantry themselves, the ease with they are propagated, the poor soil in which they will thrive, the small amount of attention which they require, and the short time in which they come to maturity, all commend them to the peasant.' In the case of such a short time crop as the sweet potato it is difficult to obtain reliable information

as to the actual acreage under cultivation. For Barbados the question was very fully discussed by Mr. J. R. Bovell in the *West Indian Bulletin*, Vol. I. pp. 204-12. He estimated that there were about 2,600 acres under sweet potatos in the island as catch and rotation crops on sugar estates, of the annual value of about $100,000 or approximately £21,000.

In the islands other than those dependent on sugar, sweet potatos also form a staple food. being to a great extent imported from those colonies in which the conditions are favourably adapted to their profitable cultivation. The sweet potato is also extensively grown in other parts of the world, for instance, the Azores, S. Africa, and the United States. According to the census return of 1890, the United States produce about 44,000,000 bushels per year.

Recently considerable attention has been given to this crop by the Imperial Department of Agriculture and, as a result, a good deal of experimental work has been carried on and more is in hand.

EXPERIMENTS WITH DIFFERENT VARIETIES.

During the last season two sets of experiments were started to test the comparative value of the various varieties of sweet potatos. These varieties are commonly recognised by local names, often indicative of some distinctive character of the potato, or of its place of origin. They differ from one another amongst other points in the shape, size, colour, flavour, and quality as a table vegetable of the root, in the shape of the leaf, in time of maturing, and in keeping power.

In connection with the Botanic Station, Antigua. fifteen different varieties—some local, others introduced—were grown in separate plots under the same conditions. The crop from each plot was weighed separately. The full results have already been published by the Department in the *Report on certain Economic Experiments in connection with the Botanic Station Antigua, 1900-1901.* The yields of each variety were calculated in tons per acre, and varied from ·6 of a ton to 1·4 tons. Amongst the varieties which occupied the foremost places were 'Eliza' and two Trinidad kinds known as 'T. 1' and 'T. 2.' respectively. The latter, although beaten by the variety 'Eliza' in actual yield, were superior in shape. The experiments will be continued. Last year the ground was comparatively new. and the variation in the yield of duplicate plots necessitates caution in estimating the relative value of the several varieties.

At Barbados a somewhat similar series of plots were laid out, under the charge of Mr. J. R. Bovell, on Waterford Estate. Twenty-eight varieties, mostly local, were obtained and 100 holes ($5\frac{1}{2} \times 5\frac{1}{2}$ ft.) planted of each. It was hoped that in the present crop season they would have been dug and weighed. A careful comparison was then to have been made as to quality as a table vegetable, shape, keeping power, etc. Unfortunately, during the past season insect pests have been more than usually prevalent on sweet potatos in Barbados. The experiment plots were ravaged by red spider and other pests and the plants seriously

injured. Even under such adverse conditions some useful information was obtained, concerning the comparative powers of resistance of the different varieties.

The field was examined by Mr. Maxwell-Lefroy in the middle of November. The sharp manner in which the plots of the different varieties were marked out owing to their varying powers of resistance to insect attack was most striking. Amongst those which had suffered the most at this time were 'Red Sealy.' 'Hurley,' and 'Caroline Lee.' About a month later many of those which were fairly free from attack in November had been damaged, but to the end 'White Gilkes' (both the three and six months varieties) and all the plots of mixed kinds, maintained their vigour in a surprising matter. From the result of this single experiment, 'Gilkes' and plots of mixed varieties seem to possess more than average powers of resistance to insect attack.

STORING SWEET POTATOS.

The usually low keeping-power of the sweet potato is a great drawback to its usefulness. The question is discussed somewhat fully by Mr. Watts in the paper already referred to. The practical result is that shortly after the time of reaping the supply of sweet potatos exceeds the demand. The greater number of the varieties will not keep long after being dug and they are sold at once at low prices to clear the ground for the succeeding cane crop. Hence for a brief period food is abundant and cheap. At other times the reverse is often the case.

'These home grown supplies are, as a rule, employed directly as food, little attempt is made to convert them into forms which will keep and thus equalize the supplies which are otherwise irregular: it seems probable that something will have to be done in this direction before much progress will be made in the substitution of locally grown for imported foods.' (F. Watts, *loc. cit.* p. 274.) The concluding words indicate the course which is pursued in equalizing the distribution of food throughout the year in those communities which can afford it, namely the importation of foodstuffs, principally from America. Mr. Bovell (*loc. cit.* p. 211) gives the value of such articles imported into Barbados (for the year 1898) as £175,011. Towards this large total, starches, grains and meals of various kinds contributed no less than about £95,000. Most of these could be raised in the Colony. In the other sugar islands the situation is very similar. American food stuffs are largely imported to supply, during certain seasons of the year, the want of local food supplies, although at other times of the year such food materials are produced in the island in excess of the demand. Unsound as this policy undoubtedly is, it will probably continue to be pursued until conditions arise which compel attention to be given to the more extensive cultivation of local food stuffs and to methods for preserving them so as to allow the supply to be regular and uniform throughout the year. The question of the storage of sweet potatos in a fresh state is one which has attracted a considerable amount of attention in different parts of the world. In the West Indies it has been

found that some varieties keep fairly well if left in the ground and dug in small quantities as required. This method has disadvantages and a better one is very desirable. The problem of storing sweet potatos is discussed in Farmers' Bulletin No. 26 of the U. S. Department of Agriculture, entitled *Sweet Potatos: Culture and Uses*, by Professor J. F. Duggar of Alabama. He says (p. 18) 'There is need for further investigation to determine the best method of storing sweet potatos, for the losses occurring during storage are sometimes enormous. The conditions in the States are however very different to those obtaining in the West Indies and although it might be of interest to put on record the methods there employed, the contrast in climatic conditions must not be lost sight of.

The best results are apparently obtained by storing the potatos in dry cellars or rooms, in which the roots are placed either with or without packing of sand, straw, hay, or other dry material. Mr. Duggar in summing up says 'Sweet potatos during storage should be kept in a dry atmosphere with ample ventilation, and a temperature between 50° and 60° F., except during the sweating period, for which time the temperature recommended by those who use artificial heat is 80° F.' Later (p. 29) he says 'The atmosphere of the storage room should be kept dry. The condensation of moisture on the roots affords conditions favourable to decay.' The essential points for success by this method of storage, namely perfectly dry conditions and a comparatively low temperature, are almost impossible to obtain economically in the West Indies where the air usually contains a very large amount of watery vapour, and the temperature is higher than in northern latitudes.

DESICCATED SWEET POTATOS.

Setting aside the possibility of keeping the whole potatos in a fresh condition, it remains to be seen whether any other economical method is feasible. Mr. Duggar describes two modes of preserving sweet potatos for use as a table vegetable. He says (*op. cit.* p. 25) 'Uncooked sweet potatos may be sliced and then dried either in the sun or in evaporators. They are prepared for the table by soaking and baking. Dried sweet potatos were exhibited among the products of Japan at the Colombian Exposition. Their preparation is described as follows:— "Cleanly washed potatos are placed in a suitable basket and immersed in boiling water for a short time: when taken out of the basket they are cut into thin slices and spread over mats and exposed to the sun for two or three days. In order to make a superior quality, the skin of the potato is peeled off before slicing." As an indication of more recent developments it may be mentioned that a company has been lately started in New Jersey, America, with a capital of $1,000,000, to make flour from sweet potatos. The early results are reported as being very successful, and it is proposed to erect mills all through the sweet potato growing region. The more important States in this region are North and South Carolina, Georgia, Texas, Alabama, Mississippi, Virginia and New Jersey.

PREPARATION OF MEAL.

The remarks above, based on the irregularity of the supply of food throughout the year, apply with especial force to Anguilla, one of the Leeward Islands, situated about mid-way between St. Kitts and the Virgin Islands. Sweet potatos are grown in Anguilla and are usually very abundant during one short season of the year. The peasants exhaust their stock during the two or three months following crop time, and for the remainder of the year are practically reduced to living on pigeon-peas (*Cajanus indicus*) and any other chance food plant which is capable of withstanding a six months' drought. The possibility of preserving the potato in a palatable form is of the greatest importance to the peasantry of this island. The experiments recorded below are, to a large extent, the outcome of a request for information and advice made by Dr. J. Numa Rat, Magistrate of Anguilla, to the Department. Great credit is due to Dr. Rat for the trouble taken by him in the interests of the island.

EXPERIMENTS IN ANGUILLA.

In November 1899, Dr. J. Numa Rat requested advice from the Department as to a good method of preserving sweet potatos. He was recommended to try slicing and drying, as described above, this process having been found to give satisfactory results in various parts of the tropics.

Early Experiments. In May 1900, Dr. Rat forwarded a box containing sweet potato meal which had been prepared in the following manner. The potatos were peeled and grated, the pulp squeezed in a cloth and then dried in the sunshine for two or three days. The dried pulp was sifted and the coarse parts powdered in a mortar. By this method twenty pounds of unpeeled potatos gave one pound of meal, that is, a return of only five per cent. The potato used for the early experiments was a variety known in Anguilla as 'Hug 'em fast.' The cost of preparation was about 1*s.* per pound.

One obvious objection to this method is the great loss of material caused by squeezing the wet pulp. This point was noted by Dr. Rat, and is emphasized in the following remarks by Professor A. H. Church, F.R.S., author of *The Food Grains of India*, etc., to whom a sample of the meal was submitted. Professor Church says 'The method of preparation involves much loss of that one constituent which one can spare least—namely, the proteid or albuminous substance. . . The expressed juice of succulent roots and tubers usually contains much soluble vegetable albumen.' A subsequent analysis of the meal by Professor Church confirmed his anticipations. The meal was found to be deficient in flesh-forming nutrients. 'The ratio of nitrogenous matter to digestible carbohydrates being 1 : 24.' Previous analyses of whole sweet potato roots had yielded the more satisfactory ratio of 1 : 13.

The detailed figures of Professor Church's analysis of the Anguilla meal are as follows: -

Water	12·6	per cent.
Albuminoids and proteids * ...	3·6	" "
Digestible carbohydrates ...	77·6	" "
Oil or Fat	0·6	" "
Fibre	3·5	" "
Ash or mineral matter †	2·1	" "

* Calculated by multiplying the nitrogen by 6·25. By the phenol method 3·5 per cent was found.

† Of this ash 0·14 was phosphorus pentoxide.

Professor J. P. d'Albuquerque. Island Professor of Chemistry at Barbados also analysed a sample of the meal with very similar results.

Later Experiments. In order to avoid if possible the loss occurring in the previous method. Dr. Rat prepared some more meal by grating the sweet potatos and sun-drying the pulp without subjecting it to pressure. This method was found to be a practicable one.The yield of meal was from fifteen to twenty per cent. of the original weight of the roots instead of only five per cent. as in the earlier method. A variety called the 'Dominique' was used instead of the 'Hug 'em fast.' The labour entailed being the same as before, but the yield four times as much, the cost of production was accordingly reduced to one quarter, namely, 4*d*. per pound of prepared meal. The meal so prepared was analysed by Professor Church. Its composition was found to be very similar to the former sample, but strangely enough it did not contain quite so much proteid matter. 'The results' Prof. Church says 'tend to show that the variety "Dominique" is inferior to "Hug 'em fast" in this respect.'

EXPERIMENTS AT ANTIGUA.

At the time when the question of converting sweet potatos into meal came into prominence owing to the necessities of Anguilla, Mr. Francis Watts, the Government Chemist for the Leeward Islands, obtained information from Mr. Spooner, of Bendals' estate in Antigua, concerning some experiments which he had previously carried out in this direction. Mr. Spooner's attention was drawn to the subject in 1898, when sweet potatos were exceptionally abundant. The main points in Mr. Spooner's method were as follows :—

The cleaned potatos were cut into slices, about $\frac{1}{16}$ of an inch in thickness. The cutting was at first done by hand but later an old chaff cutter, temporarily adapted to the purpose, was employed with very good results. The slices were spread out on galvanized wire netting and quickly dried in the sun, until quite brittle. This state was reached in six or eight hours, when conditions were favourable. They were then stored in old flour barrels until sufficient had accumulated to be worth grinding, for which an engine on the estate was utilized.

The yield of meal by this method was 40·68 per cent. of the original weight of the potatos; one ton of roots yielding

910lb. of meal. Mr. Spooner estimated the cost at £4 0. 7. per ton of meal, that is to say approximately $\frac{1}{2}d.$ per pound.

Several tons of meal were made and used with great success for feeding mules and stock. The labourers ate it readily, and Mr. Spooner says that he personally found it a palatable and satisfactory form of food. It kept well, provided the slices had been thoroughly dried before being ground, but losses were incurred when for any reason, the slices were left at all leathery instead of being perfectly brittle. The meal made from such leathery slices quickly became tainted and spoiled.

It is important to note how by the use of simple machinery the cost was reduced to such a low figure as $\frac{1}{2}d.$ per pound.

The preparation was analysed by Dr. Voelcker who reported: 'The meal is well dried containing only 12 per cent. of water and should keep perfectly well. It contains practically 10 per cent. of sugar, with 67 per cent. of starch and digestible carbohydrates, 5 per cent. of nitrogenous or protein matters with a not inconsiderable portion of mineral (bone-producing) matter. The percentage of indigestible (woody) fibre is very small.'

Dr. Voelcker's comple analysis is as follows: —

Moisture	11·90	per cent.
Nitrogenous matter *	5·12	„ „
Oil	1·19	„ „
Sugar	9·90	„ „
Starch and digestible carbohydrates	67·01	„ „
Indigestible (woody) fibre	1·89	„ „
Mineral matter (ash) †	2·90	„ „

Containing nitrogen 0·82.
† Including sand, 0·03.

The comparatively high percentage of nitrogenous matter in this sample is noteworthy. This is the element which is lacking in the dietary of many of the West Indian natives, and of which so large a proportion was lost by the Anguilla mode of manufacture.

From the above facts it will be seen that it is possible to produce from the sweet potato a meal which is palatable, digestible and cheap. It is essential that the potato should be quickly and thoroughly dried and then reduced to meal. By this treatment the greatest amount of nutritive material is retained.

For such a locality as Anguilla it is important to determine whether a meal can be made at crop time and stored for use during the period of drought. To this end it is essential to know: (1) The food value of sweet potato meal, and (2) its keeping qualities.

FOOD VALUE.

In a perfect diet the ratio of the albuminoids or nitrogenous matter to the digestible carbohydrates and sugar together should be about 1 : 4¾. This relation is spoken of as the 'nutrient ratio.' The above analyses of sweet potato meal show that its nutrient ratio is low. The first sample of

Anguilla meal gave a ratio of 1 : 24, and in the later samples it was even less. In the Antigua meal the ratio was much higher, about 1 : 15. In an analysis of fresh sweet potatos, recorded by Prof. Church in his book on *Food* the ratio is given as 1 : 18. Specimens of a Barbados variety analysed by Prof. d'Albuquerque gave as low a ratio as 1 : 50. This deficiency of the meal in proteid matter can easily be counterbalanced by supplementing it with such a food substance as pigeon-peas, which are rich in nitrogenous constituents, in common with the seeds of many other leguminous plants. In pigeon-peas the nutrient ratio is about 1 : 3. As has already been stated these peas are grown in Anguilla, in sufficient amount in fact to be an article of export. They are one of the staple foods during the dry season. Taken alone however they are not beneficial, containing too large a percentage of proteids in proportion to their carbohydrate and sugary contents. In conjunction with sweet potato meal they would make a good diet, capable of sustaining the inhabitants during the season of scarcity.

KEEPING QUALITIES.

Some of the meal prepared by Dr. Rat was sent to the Head Office of the Department at Barbados, in tins, and after about twelve months' ordinary storage was perfectly sweet and good. Mr. Spooner's testimony as to its keeping powers has already been given. There appears therefore to be no doubt that the meal, carefully prepared, will keep good for several months—a sufficient time to serve the immediate purpose of the people of Anguilla.

EXPERIMENTS IN PROGRESS.

In June of the present year (1901) the Department obtained for use in Anguilla a grinding mill and a vegetable slicer. During the coming crop season these will be tried, and it is hoped that an impetus will be given to the establishment of a regular industry in sweet potato meal, the importance of which to people situated as are the inhabitants of Anguilla, it is difficult to over-estimate.

OTHER USES OF SWEET POTATOS.

Another method of preservation, namely, canning sweet potatos has been tried on an industrial scale in America. Mr. Duggar says (*op. cit.* p. 25) 'Within recent years sweet potatos have been canned in a few localities. In 1893 a factory in Mississippi canned about 1,000 bushels using three-pound cans, which sold in Chicago at 95 cents per dozen delivered. A bushel of sweet potatos was sufficient for fifteen cans. Farmers were paid 40 cents a bushel. This firm expected to can about 8,000 bushels of sweet potatos in 1894.' Such a method whilst of interest is hardly likely to be of practical importance under present West Indian conditions.

Besides furnishing an important portion of man's diet, in many warm countries, sweet potatos are very useful as fodder for cattle and stock. Both roots and vines (foliage) may be employed to this end. Mr. Duggar, in the pamphlet already

referred to, compares the relative food-values of corn and sweet potatos. His results are expressed as follows:–

Relative Food Value of Corn and Sweet Potatos.

	Dry Matter.	Protein.	Nitrogen free extract & fat.
100lb. Corn contain ...	89·1 lb.	10·5 lb	75 lb.
300lb. Sweet potatos contain	86·7 lb.	4·5 lb.	75·3 lb.

'Thus three pounds of sweet potatos afford almost as much dry matter, quite as much carbonaceous material, but less than half as much protein, as is contained in one pound of corn. By using one-half pound of cotton-seed meal or one pound of cow-peas (seed) for every ten pounds of sweet potatos this deficiency is fully supplied.' In the West Indies at present sweet potatos are not usually regarded as a regular food for horses and cattle but rather as a special diet in cases of illness, etc. Mr. Spooner's testimony to the value of the meal as a food for stock has already been given. In the want of more exact data it would appear not improbable that it might be possible to utilize locally grown potatos, peas, etc., as fodder for horses and stock in place of much imported corn.

In England there is a certain demand for sweet potato meal for the manufacture of glucose. One firm has intimated its readiness to take as much as 1,000 tons per month, provided the price does not exceed about £6 per ton, delivered in London. This price it will be noted is very little more than $\frac{5}{8}$*d.* per pound including freight, etc. Even if the meal could be produced as cheaply as by Mr. Spooner in Antigua (at $\frac{1}{2}$*d.* per pound) it seems probable that it would be more useful and remunerative to the people in the West Indies to prepare it for their own use rather than for export at such rates.

It is interesting also to note that, owing to the failure of the orange industry in St. Michael, the famous St. Michael orange is no longer to be found in the English market. Many of the former orange growers have turned their attention to the cultivation of sweet potatos. A large portion of the crop is utilized in making spirit, which is shipped to Portugal and employed in fortifying wines, etc.

SHIPMENT TO EUROPE.

Another possible method of disposing of the surplus supply of sweet potatos has been suggested. This is shipment to Europe. In May last the initial steps were taken to secure the introduction and establishment in favour of the vegetable in the home markets. To this end a circular letter was sent to several important firms, whom it was thought might be able to co-operate. The Department offered to supply them for a certain period, with fortnightly barrels of sweet potatos entirely free of cost. The firms were requested on their side to give the potatos away in small lots, or to sell them at nominal

prices with the understanding that after say eight or ten weeks they should undertake to receive and sell a few barrels per month and sustain a regular trade in the article. The matter was actively taken up by two firms, and since October regular shipments of sweet potatos have been made.

One great difficulty to be encountered in attempting to introduce a new vegetable is lack of knowledge as how best to cook it. To obviate this the Department prepared, with the kind assistance of Mrs. J. R. Bovell, a pamphlet entitled *Recipes for cooking Sweet Potatos from the West Indies* which was issued as as No. 6 of the Department's Pamphlet Series in July 1901. It contains fifteen different ways of preparing the vegetable for table use. Copies have been widely distributed with the potatos. The Department has been fortunate in securing the hearty cooperation of several of the planters of Barbados in this matter, as also of the Royal Mail Steam Packet Company, who have agreed to carry the barrels of potatos free of cost during the early stage of the experiment.

It remains to be seen how much demand there is for them in England. Supposing the trade to grow, many points as to the best modes of packing, the best varieties for transporting, etc., will require to be solved. The Army and Navy Auxiliary Cooperative Supply, Limited of London have regularly contributed valuable information concerning the condition in which the potatos have reached England

Preference has been already expressed in England in favour of small, red potatos. One important point to remember is the comparative ease with which the sweet potato can be bruised. It therefore demands careful handling.

The experiment has been commented upon in several of the English papers, and the following notice appeared in the West India Committee's Circular for Nov. 12, 1901 :—

'With a view to popularising this vegetable in the United Kingdom Dr. Morris, the Imperial Commissioner of Agriculture for the West Indies, has arranged to send over by each mail for the present a few barrels of sweet potatos. Samples of these potatos with full culinary recipes may be obtained from Messrs. James Phillips & Co., 4, Fenchurch Street Buildings, E.C. Members of the Committee will greatly assist in the encouragement of what may become an important minor industry by bringing the sweet potatos before the notice of their friends who have not had the advantage of sampling them in a tropical country.'

LECTURES TO PLANTERS.

In response to a request received from the Barbados General Agricultural Society a series of Lectures to Planters were recently given by some of the officers of the Imperial Department of Agriculture for the West Indies. The lectures were delivered in the Planters' Hall, Bridgetown. They were intended to afford to planters information and assistance in

elucidating scientific problems which underlie the agricultural practice in which they are daily engaged.

The majority of the lectures were presided over by His Excellency Sir F. M. Hodgson, K.C.M.G., Governor of Barbados, who had lately become Patron of the Society. The interest taken by the planting community was evident from the large attendance from all parts of the island.

The lectures were fully illustrated by large botanical and entomological drawings, specially prepared by Mrs. W. G. Freeman, A.R.C.S., specimens, and in the case of the lectures on soils and manures by chemical experiments.

The complete course of lectures was as follows :-

Lect. 1. –July 23, 1901.
The Natural History of the Sugar-cane.
By Dr. D. Morris, C.M.G., M.A., D.Sc., F.L.S.

Lect. 2. August 6.
Soils and Manures in relation to the cultivation of the Sugar-cane. Part i.
By Prof. J. P. d'Albuquerque, M.A., F.I.C., F.C.S., Island Prof. of Chemistry, Barbados, in Chemical charge of Sugar-cane experiments.

Lect. 3.—Sept. 3.
Soils and Manures in relation to the cultivation of the Sugar-cane. Part ii.

Lect. 4.—Sept. 10.
Soils and Manures in relation to the cultivation of the Sugar-cane. Part iii.

Lect. 5 Sept. 17.
Hints on the planting and cultivation of the Sugar-cane and Intermediate Crops.
By J. R. Bovell, F.L.S., F.C.S., Agricultural Superintendent of Sugar-cane Experiments.

Lect. 6. October 1.
The Insect Pests affecting the Sugar-cane and Associated Crops.
By H. Maxwell-Lefroy, B.A., F.E.S., Entomologist to the Department.

Lect. 7.– October 15.
The Fungoid Diseases of the Sugar-cane and other West Indian Crops.;
By Albert Howard, B.A., A.R.C.S., F.L.S., F.C.S., Mycologist to the Department.

The text of the lectures will shortly be published in book form, with reproductions of the drawings, and of the apparatus employed to illustrate the lectures, in chemistry. A brief résumé however of some of the more important points of each lecture, may be useful.

THE NATURAL HISTORY OF THE SUGAR-CANE.

Dr. Morris first briefly explained the objects of the lectures. They were intended to assist, as far as possible in

improving the cultivation of practically the only plant which at present appeared capable of maintaining the prosperity of Barbados, namely, the sugar-cane. He believed that it was possible to maintain that prosperity if all steadily combined to improve the character of the cane plant, its methods of cultivation, and the processes of making sugar from it. He should confine himself to the natural history of the sugar-cane, leaving it to the other lecturers to take up special parts and give information concerning soils and manures, the cultural requirements of the cane, and the diseases and pests to which it was subject. The lectures were primarily intended for young planters; he hoped however that they would be of service also to the older planters for we must all learn if pace was to be kept with the advances in agriculture in the present day. The motto of the Imperial Department of Agriculture was 'Education and Research.' The workers in the Department desired to assist and advise the planters so as to enable them to compete successfully with other countries. This could only be done first of all by education—leading to the best methods of treating the cane as a source of sugar, and secondly by reliable results based on thorough and exhaustive experimental research. To put it briefly the cultivation of the sugar-cane to be successful must be placed on thoroughly scientific lines. A sugar planter, to succeed at all must of necessity be 'practical,' that is to say he must be thoroughly well acquainted with all the working details of his occupation, but the most successful planters, were those who, while being practical, made in addition the fullest and most discriminating use of the teachings of science. Such men were practical first, and scientific afterwards. When science was grafted on practice we had an ideal combination which could hold its own even in times of depression.

Turning to the more particular subject of his lecture, Dr. Morris gave a short account of the history of the cultivation of the sugar-cane tracing the steps by which it was eventually introduced into Barbados about 1640. The external character of the plant was described, its division into root, stem, leaf and inflorescence. The internal structure of the various parts was dealt with sufficiently to allow the physiological functions of the respective organs to be treated of in a simple and clear manner.

Reference was made to the confusion in the present nomenclature of cane varieties, due in great measure to the same cane being grown in various parts of the world under different names. In this connection Dr. Morris exhibited coloured drawings of West Indian canes. These formed part of a series now being prepared by Mrs. G. A. Goodman, the expenses being defrayed by a subsidy from the Government Grant Committee of the Royal Society of London. The drawings are life size, exhibiting the special characters of the canes, and coloured true to nature. The canes from which they are made are selected as typical plants by Mr. J. R. Bovell, Agricultural Superintendant of sugar-cane experiments. It is hoped that when sufficient material has been accumulated from all parts of the world it may be possible to reduce the numerous so-called varieties to a comparative few.

SOILS AND MANURES IN RELATION TO THE CULTIVATION OF THE SUGAR-CANE.

Professor d'Albuquerque pointed out that the aim of the planter was to enable the cane to produce its maximum quantity of sugar. To this end it was necessary to provide the elements of plant food in their most favourable form and to put the plant under the best possible conditions for its life processes. Many important factors were, however, beyond the planter's control, for instance the composition of the atmosphere. the quantity of available sunlight, the temperature and the rainfall. In practice he was confined to the cane plant itself and the soil in which it grew. Obviously the first essential is to secure a good variety of cane. Having done this the planter must learn as much as possible about the soil to enable the cane to produce its full yield of sugar.

The origin and formation of soils were first dealt with and the part played the atmosphere, rain, flowing water, alternations of temperature, and the activities of vegetation and soil organisms explained.

The methods of the mechanical analysis of soils were shown, and the significance of the terms used in recording the results of an analysis pointed out, as a means of estimating the value of a soil. The chemical analysis of soils were also treated of, and the distinctions between 'available,' 'potential' and 'non available' plant food emphasized.

The important subject of the retention of soluble plant foods by the soil received adequate experimental demonstration. In particular the important difference in this respect between nitrate of soda and sulphate of ammonia was clearly shown.

Questions bearing on the physical properties of soils, such as cohesion, permeability, retentiveness, and capillarity, were experimentally dealt with, and discussed in relation to agricultural operations.

On the biological side the role of earthworms in the soil and their usefulness in converting subsoil into fertile soil were explained. Bacteria as soil organisms were dealt with at length, and in discussing them information was given over such a wide range of important topics as nitrification, farm yard manure, denitrification, leguminous plants and nitrogen assimilation, green dressings and nitragin.

The soil was next treated of as a storehouse of water, which led naturally to a discussion of the operations of drainage and tillage. The use of the various agricultural implements in these operations was pointed out, together with the resulting effects on the soil.

Professor d'Albuquerque now turned his attention to the modes of improving soils. He showed that the difficulty of working clay lands was due to the relatively enormous surface area presented by its minute constituent particles. If the particles could be made to cohere in little groups, the surface area would be reduced. Such a result was obtainable by the addition of lime which caused the particles to flocculate and thereby rendered tillage easier. Lime moreover improved many

soils by its chemical action, and the comparative value of the various sources of lime was discussed. The composition of farm yard manure was treated of, and the great importance of its humus contents insisted upon. Its beneficial action on the land was, Professor d'Albuquerque explained, seen not only in the year of application but also in succeeding years. The addition of farmyard manure was therefore a source of lasting improvement to the fertility of the soil.

Leguminous plants were discussed both as green dressings, and as fodder, and their return of nitrogen and humus to the soil dealt with in each case. After indicating how the general facts of the chemical requirements of the sugar-cane have been established, the artificial manures most employed by sugar-cane planters were successively dealt with in detail, and general recommendations made for the manuring of the sugar-cane. The valuation of manures and the rotation of crops also received notice. An interesting feature was a balance sheet showing clearly what was taken from and what was added to the soil. in the normal course of cane cultivation and sugar manufacture as practised in Barbados.

HINTS ON THE PLANTING AND CULTIVATION OF THE SUGAR-CANE AND INTERMEDIATE CROPS.

The central point of Mr. Bovell's lecture may be realized from the following table :-

Average Cost of Production of a Ton of Canes.

	s.	*d.*
Barbados (75 per cent. of the estates) ...	13	6
Antigua	11	0
Queensland	10	0
Trinidad	9	6
Jamaica (2 estates)	5	6

Average Value of a Ton of Canes.

	s.	*d.*
Barbados...	12	3

The detailed figures by which Mr. Bovell arrived at his estimate of the average cost of production in Barbados are given in the *West Indian Bulletin*, Vol. I. pp. 61-76. The estimate was received with incredulity at the time as being too high. The figures have since been proved to be correct, or if any thing to be slightly below the actual cost. The estimates given for other countries are obtained from reliable published sources.

Comparing the average cost of production and the average value of a ton of canes, we find that, taking the island of Barbados as a whole, *there is an actual loss* of 1*s.* 3*d.* per ton of canes grown. The cost of production appears exceptionally high in Barbados, and as a means of reducing this, so as to render it possible to grow canes at a profit, Mr. Bovell directed attention to various debatable points in present procedure in cane cultivation. Taking in succession such cultural operations as planting canes, drainage, green manuring, etc., he discussed their cost, their practical utility, and with each put the

question to planters as practical men. Does it pay? Do the results justify the expense? Is there no better or cheaper method by which as good or better results can be obtained at less expense? Improvement in this direction was, he urged, absolutely essential if the industry was to be profitably maintained.

In dealing with sweet potatos and yams, many practical points of importance were treated of, such as which portion to plant, the best manures and modes of applying them, etc. One line of work which the Department has in hand at present was illustrated by an exhibit of some 28 kinds of sweet potatos, with their roots and the foliage belonging to each.

Indian corn was the last crop dealt with. This is often looked on as an unprofitable crop. Yet it was shown that corn which will sell at about 80 cents per bushel can be grown for about 12 cents, whilst American corn is imported on a very large scale and sells for about $1.00 per bushel.

In conclusion Mr. Bovell said that whilst in the past it was no doubt economically sound to buy cheap American corn and oats with dear sugar, it was now, with the present price of sugar, a wrong policy, and one which tends to keep up the cost of production of the staple crop.

THE INSECT PESTS OF SUGAR-CANE AND ASSOCIATED CROPS.

Mr. H. Maxwell-Lefroy at the outset pointed out that in discussing remedies for pests, three considerations must be kept in view. The remedy must be effective, it must be simple, and it must be cheap. In dealing subsequently with the insect pests of Barbados these three points were kept prominently in view. For instance with the moth-borer in sugar-cane, two methods stood out above all others in effectiveness, simplicity and small cost, namely, cutting out dead hearts and collecting the eggs. Figures showing the cost of these remedies in actual practice on estates were given.

Of other sugar-cane pests, the weevil borer and lady-bird borer, and the root borer were discussed; their life history, such as we know it, traced, and possible remedies suggested.

The pests of the sweet potato and Indian corn were similarly treated of.

Mr. Lefroy advocated the adoption of methods of destroying insects as part of the ordinary routine work of the estate, insect pests being animal life in the wrong place just as much as weeds were plant life in the wrong place, and equally demanding extirpation.

Finally, the origin of insect pests was discussed from a general standpoint, and the part played by man in introducing new cultivations and upsetting the balance of life pointed out.

FUNGOID DISEASES OF SUGAR-CANE AND OTHER WEST INDIAN CROPS.

Mr. Howard dealt first with the general question of disease in plants, which is a state of affairs due to interference with the normal life processes of the organism. The charac-

teristics of the group of fungi were shortly sketched, the differences between parasites and saprophytes being emphasized. The manner in which the fungi could interfere with the vital processes of other plants, and so cause them to become diseased, was then discussed together with the ordinary methods of combating such attacks. The rind and root diseases of the sugar-cane were discussed with suggested remedies.

The conclusion of the lecture was devoted to the possibility of raising canes of higher disease-resisting power than many of those at present in cultivation.

CITRATE OF LIME AND CONCENTRATED LIME JUICE.

BY THE HON'BLE FRANCIS WATTS, F.I.C., F.C.S.

Government Analytical and Agricultural Chemist to the Leeward Islands.

The question of the manufacture of citrate of lime for export in place of the concentrated lime juice is of the greatest importance to such West Indian islands as Dominica and Montserrat. It has been thought advisable to reprint in these pages an article by Mr. F. Watts which originally appeared in the *Bulletin of the Botanical Department, Jamaica* Vol. V. 1898 pp. 263-9. To this article Mr. Watts has written an addendum containing the results of more recent inquiries into the subject :—

Some attention has lately been directed to citrate of lime and it has been suggested that this should form an article of export from Jamaica. It is well known that lemon and lime juice constitute the raw material from which citric acid is manufactured; these juices usually contain from 10 to 15 ounces of citric acid per gallon, sometimes exceeding these limits from exceptional causes ; if exported in this condition the cost for freight and packages would be exceedingly high, hence efforts are made to obtain the citric acid in a more concentrated form. Three methods of doing this have been suggested, concentration of the juice by boiling, the preparation of citrate of lime, and finally the preparation of citric acid in the country where the fruit is grown. The first two have for their object merely the production of raw material for the manufacturer in a concentrated form.

The preparation of concentrated lemon and lime juice is a very simple matter: The juice is passed through strainers to remove seeds and floating impurities, and is then boiled down to a proper degree of concentration, in copper or iron vessels, over open fires much in the same way that cane juice is evaporated in the old fashioned muscovado process of sugar-making. When several evaporating vessels are placed in a series over the same fire, forming a battery, it is important to notice that the vessel or pan in which the juice is brought to its

highest state of concentration is furthest from the fire; while that containing the fresh juice is over the fire itself, thus a battery for lime juice is hung in the reverse way to a sugar battery.

In concentrating lemon juice efforts are made to obtain a product containing 64 ounces of citric acid per gallon, this being regarded as the standard strength, and a pipe of 108 gallons being regarded as a standard package; hence when the market price of concentrated juice is quoted at so much per pipe these standard quantities are assumed. In reality these quotations refer to an arbitrary quantity of 432 pounds of citric acid. In the production of concentrated lime juice in the West Indies it has been the practice to carry the concentration to a higher degree than this, so that concentrated lime juice usually contains upwards of 96 ounces per gallon; a good rule in practice is to endeavour to produce concentrated juice which will have a uniform specific gravity of about 1·300. In dealing with lime and lemon juices a particular form of hydrometer, known as a citrometer is frequently made use of, though its use is less common than formerly. Knowledge of the origin of its scale and the meaning of its indications appear to have been lost; from experiments which I made some years ago I came to the conclusion that the instrument is so constructed that when placed in hot (boiling) lemon juice it will indicate the same degree as a Twaddel's hydrometer will show when floating in the same juice in the cold. It is thus a useful instrument in the hands of the man in charge of the concentrating pans, for he can from time to time test the juice rapidly, in a hot condition, and arrest the boiling when the citrometer indicates the same degree which on a Twaddel's instrument will correspond to the specific gravity 1·300; this of course is 60°. Hence the rule for concentrating becomes:—Carry on the concentration until the citrometer, when immersed in the juice at the boiling temperature, shows a density of 60°. The product thus obtained is a dark, nearly black, thick liquid.

It is often urged that there is very considerable loss of citric acid when juice is treated in this manner. My own experiments lead me to suppose that when juice of good quality is treated, the loss is about 7 to 8 per cent. of the original acid; when juice of poor quality is dealt with, this loss may reach 10 or 12 per cent. probably owing to the greater length of time required to concentrate the poorer juice to the required density. If concentration is carried beyond the point indicated the loss rapidly increases. The concentration here recommended is that which I believe to afford the maximum concentration with the minimum loss of acid.

The concentrated juice should be thoroughly cooled before being placed in casks or the casks will leak: indeed leakage from the casks is one of the most serious troubles which the maker of concentrated juice has to contend with. Casks containing 54 gallons are usually employed.

The suggestion that the concentration of the juice should be conducted in steam-heated evaporators naturally occurs: it is open to question whether these would offer such advantages

as would compensate for the increased complication and expense of the plant: the loss of acid from over heating might be reduced somewhat. Only when the manufacture is conducted on a very large scale will the question of the use of steam evaporators arise, and here it might be desirable to conduct the first part of the evaporation over an open fire, while finishing the evaporation of the thick juice in steam heated pans.

The process as now conducted is a simple one, its defects are that it necessitates the employment of a considerable quantity of fuel, it involves the loss of about 8 per cent. of acid, the product is dark in colour, is liable to leak from the casks and requires expensive packages.

In order to minimise these defects it has been proposed to conduct the first part of the manufacture of citric acid on the spot, and produce citrate of lime. This idea has been afloat for upwards of thirty years; in the last few years it appears to have been acted upon with some degree of success: in fact it is stated that this article has entirely taken the place of shipments of concentrated lemon juice from Palermo.

I am unable to ascertain the actual quantities imported into England and other European countries, but Messrs. Gillespie Bros. & Co. of New York, who have made inquiries on the subject, inform me that the imports into the United States for the past few years have been as follows:

Years.	Quantities. Lb.	Values. $	Value per unit of quantity
1887	42,558	6,001	·11
1889	47,890	8,569	·18
1891	28,858	4,837	·15
1892	220,468	30,450	·14
1893	639,789	75,271	·12
1894	448,891	52,137	·12
1895	608,214	59,458	·10
1896	668,106	66,888	·097
1897	196,291	12,090	·085
1898	1,026,467	84,780	·082

Up to the present this appears to have been entirely produced in Italy or Sicily, none having been imported from the West Indies.

The preparation of citrate of lime is the first step in the manufacture of citric acid from lemon or lime juice. We are well aware that when the juice of the sugar-cane is concentrated to a sufficient degree, the active principle, cane-sugar, separates out in the form of crystals; the active principle of lemon or lime juice, citric acid, will not separate in a crystalline form when the juice is simply concentrated, owing to the presence in the juice of a large quantity of gummy or pectic impurities. In order to overcome this difficulty the citric acid is brought into combination with lime, the citrate of lime thus formed being insoluble in water can be separated from the gummy matters which remain dissolved. In order to effect this the juice is neutralised with chalk, the resulting citrate of lime is allowed to subside and finally separated by straining by

means of linen or canvas. The resulting citrate may now be dried for shipment or be treated with sulphuric acid for the manufacture of citric acid.

Simple as the above process appears, there are many practical difficulties, particularly in the preparation of the dried citrate for export.

In the first place the chalk employed must be of very fine quality, free from magnesium salts and from more than a trace of iron, alumina, and phosphates. Either of these impurities exercises a prejudicial action at one or other stage of the manufacturing process. Again, the chalk must be of such a quality that it can be readily mixed into a cream with water; it must be free from lumps. In order to obtain chalk of proper quality English or French levigated whiting was for a long time imported into Italy and Sicily for the preparation of citrate of lime: now, however, I believe suitable forms have been found closer at hand. To get over the difficulty of obtaining chalk possessing the necessary fine powdery character and the requisite purity, the use of slaked lime suggests itself, this latter substance occurs in the form of a fine powder, easily mixed with water and can be obtained in a state of great purity; in default of other pure sources of supply, coral may be used, this will yield lime containing a negligeable amount of impurity. Analyses of several kinds of coral showed carbonate of lime 95·37 to 98·07 per cent., phosphate of lime ·32 to ·84 per cent., organic matter 1·98 to 3·79 per cent.

Should slaked lime be used, care must be taken not to neutralise the juice completely or impurities will be precipitated with the citrate, and these impurities will interfere with the subsequent manipulation and the production of citric acid: where slaked lime has to be employed it would appear desirable to complete the neutralisation with chalk, using the lime only for the neutralisation of the greater part of the acid.

In producing citrate of lime, the lime or lemon juice is placed in a suitable mixing vessel, large enough to prevent loss from overflow from the foaming effervescence which takes place when chalk is added. A sufficient quantity of chalk is made into a cream with water and the mixture poured cautiously into the juice with constant stirring, proceeding cautiously as the acid is neutralised. There is some difficulty in ascertaining when the exact point of neutralisation is arrived at, for in the presence of certain impurities, notably phosphate of iron, the juice remains acid although an excess of chalk may have been added. To ascertain how much chalk is to be used it is best to proceed as follows:—when the greater part of the chalk has been added, the mixture is well stirred and the effervescence is allowed to subside, a small quantity is then taken out and tested by the addition of little of the mixture of chalk and water; if this produces an effervescence, more chalk must be added to the main quantity, proceeding cautiously and testing at intervals, until no effervescence is produced. A further test is now made,—a little of the mixture is withdrawn and heated, as soon as bubbles of gas cease to be given off, a few drops of acid, fresh lime juice will answer, are added;

this will produce a slight effervescence if chalk has been added in right amount, and a brisk effervescence if too much has been used. In the latter case, more juice must be added to the mixture and the process of testing repeated.

Having added the correct quantity of chalk it is desirable to heat the mixture for a few minutes nearly to boiling point, actual boiling is not necessary ; this causes the citrate of lime to become crystalline and to subside rapidly in a condition in which it is easily manipulated.

In the earlier attempts to prepare this substance the heating at this stage was omitted, the juice was neutralised, and the citrate of lime was separated from the cold liquor and dried. In consequence of this method of working, the finished citrate contained many impurities, it dried in the form of hard lumps or of a powder full of hard knobs so that grinding had to be suggested, it was difficult to powder and when thrown into water it was wetted with difficulty so that the manufacturer had difficulty in acting upon it with sulphuric acid when converting it into citric acid. Owing to the presence of impurities the citrate often became dark on drying, and yielded a dark coloured liquor in the citric acid factory, a liquor which filtered with difficulty. All these features were very objectionable to the citric acid maker, and led him to prefer concentrated juice to citrate of lime as his raw material. Heating, by rendering the citrate crystalline, permits of its purification, many of the impurities are removed with the water and can be easily washed away. It seems very important that heat should be used at this stage; it is probably due to its omission that the earlier experimenters with citrate of lime encountered so many difficulties.

As soon as the citrate is seen to become crystalline and subside rapidly the heating is stopped, the citrate quickly settles leaving a clear yellow liquid above, this liquid is poured off or syphoned off, as much water being removed as possible. Washing the citrate a few times with hot water is advantageous ; this removes the gummy matters which cause the citrate to cake into lumps in drying and which may give rise to darkening in colour and the subsequent production of dark and troublesome citric liquors in the manufacture of acid. The earlier samples of citrate contained so much impurity and were so difficult to manipulate that they found little favour with manufacturers.

The method of dealing with the citrate at the next stage of the process will depend entirely upon the scale upon which the manufacture is conducted. When the operation is conducted on a small experimental scale, the citrate may be thrown upon a stout cloth supported on a sieve or strainer, as soon as the water has drained away the residue is tied or folded securely in the cloth and submitted to pressure, to remove as much water as can be thus got rid of.

When a large quantity of citrate is made, a filter such as is used in citric acid works, may be employed. This consists of a 'deal floor with boards round the edge; the floor has one inch splines nailed on it one inch apart, and canvas (36 in.,

"forfar") is stretched on the splines; a convenient size is 16 ft. by 12 ft. by 1 ft. deep. It should be slightly tilted, and exit holes provided.' (Grosjean.) The citrate is allowed to drain upon the filter; when draining ceases the substance is put into canvas bags and submitted to pressure.

On a large scale it will be found more convenient to use filter presses; by their use the combined operations of filtering and pressing can be expeditiously performed, a great saving of time and labour can be thus effected, while the factory can be rendered much more compact owing to the small area occupied by the filter presses as compared with the space required for filters and the presses for the bags.

After as much water as possible has been pressed from the citrate by whatever process is adopted, it has to be dried. This part of the process demands great care, and is attended by considerable risk of loss; there is great tendency on the part of the citrate, when in a damp state, to ferment; as a result of this fermentation, the citric acid is destroyed and carbonate of lime, the original chalk from which the manufacture started, is left; there is little to indicate to the eye that this fermentive change is taking place, so that an unskilled or careless operator may find his finished product to contain no citrate of lime at all, but to consist entirely of chalk. To avoid this risk of loss it is only necessary that the citrate of lime should be brought quickly into some form of drying apparatus where a temperature of from 150 to 200 F. (66° to 93 C.) can be maintained, while at the same time there is a free circulation of air through the drying chamber in order to carry away the moisture. For a long time the difficulty of obtaining a satisfactory and efficient drying apparatus was a great stumbling block: the problem of drying the citrate of lime is very similar in its nature to that of drying fruit, so that a good fruit dryer will answer well for experimental purposes, while larger forms of apparatus, worked upon the same principles, can be constructed for use where the manufacture is conducted on a large scale. Where much work is to be done it would appear desirable to have several sets of drying apparatus, so that one lot of material may be thoroughly dried before it becomes necessary to introduce fresh, wet citrate into the same apparatus. Any form of apparatus in which the temperature can be maintained at from 150 to 200 F., or even somewhat higher, while at the same time permitting sufficient ventilation to remove the moisture rapidly, will prove efficient. It is important to lay stress on the ventilation. As has been stated, the proper drying of the citrate is of paramount importance; should it remain damp, or in any way become damp from careless handling, or careless storing, fermentation will speedily spoil the product.

Messrs. Warrington and Grosjean* made an investigation of the amount of water remaining in citrate of lime dried at 212 F. (100 C.) They found this to range from 5·90 to 7·68 per cent. This exists as water of crystallisation; when dried at 392 F. (200 C.) the substance contained no water. Fermen-

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* *Journ. Chem. Soc.*, Oct., 1875.

tation readily takes place if more than 12 per cent. of water is present, there is however no danger of fermentation as soon as the proportion of water has been reduced to 10 per cent. but it is desirable to continue the drying until less than that amount exists: if the temperature of the drying apparatus cannot be raised above 212 F. the product, as shown by the investigations just referred to, may contain over 7 per cent. of water; if, however, the drying can be finished at a higher temperature, say from 248 to 302 F. (120 to 150 C.) the proportion of water may be reduced to below 5 per cent. Efforts should be made to secure this thorough drying.

When prepared in the manner described citrate of lime is a white powder free from hard lumps; when thrown into water it is easily wetted and is readily diffused through the liquid on stirring. If kept in a dry place it will remain good indefinitely. For shipment it should be tightly packed in paper-lined barrels. It should contain over 60 per cent. of citric acid; a sample prepared by myself contained 65·5 per cent. of citric acid, 2·5 per cent. of other organic acids, and ·5 per cent. of carbonate of lime. Warrington states that the best sample of commercial citrate he has met with contained 72 per cent. of citric acid, and this is about the highest percentage that can be reached when the citrate contains no excess of chalk and has been thoroughly dried.

Citrate of lime is bought and sold on the same basis as concentrated lemon and lime juice, namely on the basis of citric acid contained. Quotations are made for the same arbitrary quantity as in the case of concentrated juice. In this case the standard is the cask of 675 pounds of citrate, containing 64 per cent. of citric acid; this being equal to 432 pounds of citric acid As to price, citrate sells at about the same rate as concentrated juice, sometimes realising a little more, sometimes a little less than that article.

From the point of view of the manufacturer of citric acid, citrate of lime possesses some advantages over concentrated juice. It can be stored without loss, while juice is liable to leak from the casks: the first stage of the manufacture of the acid has been already completed and the manufacturer can dispense with the neutralising vats and the filters, thus there is much economy of space and of labour. Finally, owing to the fact that citrate of lime is white, while concentrated juice is black from the charring action of the heat used in its production, the resulting citric liquors obtained from citrate are a better colour, yielding whiter crystals of citric acid, thus reducing the operations of refining the citric acid and saving both labour and material.

Possessing these advantages it seems probable that citrate of lime will ultimately displace concentrated juice, provided that an article thoroughly suited to manufacturers' requirements is produced; as competition becomes keener in the production of raw material—and this is likely to ensue from the attention being given to tropical products and the difficulty experienced in finding new and profitable ones—there will arise competition between these two forms of raw material,

when the preference which the manufacturer of citric acid will give to well prepared citrate will no doubt enhance its value in comparison with concentrated juice. Hitherto the production of citrate of lime has been relatively small so that competition between the two forms of raw material can hardly be said to exist. It is not unlikely that this condition may be altered in the near future.

It has been proposed to undertake the manufacture of the citric acid itself in the countries where the juice is produced; this offers many obvious advantages, but at the same time is beset by some difficulties. The chief difficulty would appear to be a trading one: the manufacture of citric acid is in the hands of a few firms against whose interests small manufacturers could not contend, so that the probability of citric acid being made in the countries producing the raw materials seems remote unless the venture is undertaken by one of the already established citric acid-making firms.

The discussion of the pros and cons of this question would be too lengthy and technical to be profitably dealt with in this article; I therefore propose to reserve it, if necessary, for future consideration.

Since the foregoing article was written I have had opportunities of making further inquiries the results of which may fittingly be added.

I find that in Dominica it is customary to carry the concentration of lime juice to a higher degree than 64 oz. per gallon. Concentrated juice from this island ranges in strength from 105 to 120 oz. per gallon, or even higher. That such a degree of concentration is attainable without considerable loss is due to the fact that juice of good quality is used for concentration: on many estates in Dominica the whole of the juice obtained is concentrated, whereas in some places the finer qualities are exported as raw juice while the inferior ones alone are concentrated. These finer juices will contain larger proportions of acid in relation to the other soluble matters present, and therefore when concentrated to a definite specific gravity will contain more acid than concentrated juice derived from raw juice of lower grade.

Buyers point out some defects of West Indian concentrated juice; one is the presence, at times, of considerable quantities of pulpy matter, seeds and other impurities; another defect lies in the presence in some samples of noticeable quantities of iron.

Some buyers informed me that they were of opinion better prices, both for concentrated juice and for citrate, may be obtained if the West Indian trade were better organised, their experience being that small lots of concentrated juice appeared on the market at somewhat irregular times, so that buyers were unable to be on the look out for, or to depend on the arrival of West Indian supplies. These lots often arrived when

there was no particular demand and after buyers had made their contracts; they therefore sold with difficulty and at lower prices. This may be remedied by better organisation, by such methods as making contracts beforehand, by the careful use of marks and brands, by intimations in trade journals of the conditions of crops, their probable quantity and the probable times of arrival in the market.

So far as I could learn it appeared possible to make contracts for the delivery at specified dates of lots equal in size to about 25 casks and upwards of concentrated juice as shipped from the Leeward Islands. These contracts are made, I understand, from about January to April. It is interesting to note that this year (1901), contracts were made for Italian and Sicilian supplies at about £17 to £19 per pipe, while later in the year the market had fallen to about £13. It seems, therefore, highly probable that better prices may ultimately be obtained for West Indian juice by a closer acquaintance with British market conditions and by the preparation of high class products in connection with known marks and brands.

I have little to add concerning the preparation of citrate of lime: those whom I have consulted emphasise the importance of washing the citrate with hot water before drying: if this is not done thoroughly very troublesome colouring matters may be present in the citrate and in practice these may be more difficult to remove than the colouring matters which are encountered when working with concentrated juice. If attention is paid to this and a well prepared and well washed citrate, free from impurities, is put on the market there is little doubt that in a short time it will command a better and readier sale than its competitors.

A cacao drier, similar to the one recently erected at the Botanic Station in Dominica, would doubtless serve admirably for the drying of both citrate and cacao.

It is now being made a condition that citrate must not contain more than two per cent. of free chalk, a penalty being imposed if this amount is exceeded. The exact rate at which this penalty will be levied does not appear to have been yet agreed upon.

As regards price, citric acid, whether in the form of concentrated juice or of citrate of lime, has practically the same market value. Citrate of lime is quoted in terms of the standard cask of 305 kilos. (675 lb.) containing 64 per cent. of citric acid; a standard cask therefore contains. 480½ lb. of acid. Concentrated juice is quoted in terms of the pipe of 108 gallons containing 64oz. of citric acid per gallon, being equivalent to 482 lb. of acid; the quantities are practically identical. At present these two commodities command approximately equal prices; sometimes one, sometimes the other having a slight advantage. I understand that an import duty is imposed on citrate entering France while concentrated juice is admitted free, in consequence of which concentrated juice may at times command a slightly higher price in European markets.

During 1899 prices ranged from	£13	to	£20	per pipe or cask.
„ 1900 „ „ „	£13	„	£17	„ „ „ „
„ 1901 „ „ „	£17	„	£19	„ „ „ „

The figures for this year are those for January to April when most of the contracts were made: since then they have gradually fallen to about £13.

Under these circumstances the West Indian producer. in deciding which article he shall make, must ascertain the difference in cost of production and whether the buyers are likely, at an early date, to prefer one article to the other. As matters stand at the present moment I anticipate that citrate will prove more expensive in preparation than concentrated juice, the cost of erecting steam heating apparatus and drying chambers and of importing and transporting lime or chalk will more than counterbalance the saving of fuel, the reduction in cost of packages and the saving of acid destroyed in the process of concentration. Nevertheless we have the evidence afforded by Italy and Sicily, the principal sources of supply, where the production of citrate is making steady headway and where, I am informed, the process is found to be better and cheaper than simple concentration. The exports of both articles from Messina and Catania have recently been as follows: —

Dec. 1. 1899. to Sept. 30, 1900.	Concentrated juice	1,671	pipes
Citrate of lime 635½ tons - ...	... ..	2,085	„
	Total ..	3,756	„

Dec. 1, 1900, to Sept. 30, 1901.	Concentrated juice	519	pipes
Citrate of lime 590¼ tons - ...	... ...	1,969	„
	Total ..	2,518	pipes

It seems to me highly probable that the manufacturer of citric acid will ultimately show a decided preference for citrate of lime and this as soon as the manufacture of citrate in Italy and Sicily is placed upon a sure footing so that citrate of uniform and dependable quality comes steadily to market: when that point is reached citrate will begin to command higher prices than concentrated juice. West Indian producers will then have to produce citrate if they wish to obtain the best prices for their goods. This time may not be far distant, for the experiments of the last thirty years have removed most of the difficulties which were encountered, while during the last ten years the advance has been very marked on the commercial side.

The table on the following page is added in order to facilitate calculations dealing with the acidity of raw juice. In some places it is customary to speak in terms of ounces of citric acid per gallon of juice, in others in terms of grains per ounce.

TABLE SHOWING THE QUANTITY OF CITRIC ACID IN GRAINS PER OUNCE, EQUIVALENT TO OUNCES PER GALLON, AND VICE VERSA

Ounces per gallon	Grains per ounce.	Grains per ounce	Ounces per gallon.
8	21·875	20	7·311
8·5	23·242	22	8·045
9	24·609	24	8·777
9·5	25·966	26	9·508
10·	27·341	28	10·239
10·5	28·711	30	10·971
11	30·078	32	11·702
11·5	31·445	34	12·434
12·	32·813	36	13·165
12·5	34·180	38	13·897
13	35·547	40	14·628
13·5	36·914	42	15·359
14·	38·282	44	16·091
14·5	39·649	46	16·822
15·	41·016	48	17·554
15·5	42·383	50	18·285
16·	43·750		
16·5	45·117		
17·	46·484		
17·5	47·851		
18·	49·219		

Difference for ½ ounce per gallon = ·683 grains per ounce. Difference for 1 grain per ounce = ·365 ounce per gallon.

SUGGESTIONS FOR INSECT CONTROL IN THE WEST INDIES.

BY H. MAXWELL-LEFROY, B.A., F.E.S.

Entomologist to the Imperial Department of Agriculture for the West Indies.

THE subject of the insect pests of West Indian crops has received but little attention in the past. When in by-gone years 'blight' attacked a wide area of a staple crop, such as the sugar-cane, there would be an increased interest in this subject, leading rarely to an investigation by a commission or by some private person, whose information and recommenda-

tions received attention at the time, only probably to be forgotten soon after. In this way there have been, at recurring intervals, local renewals of interest in sugar-cane diseases: many people have added their quota to the recorded knowledge and in some cases the advice of experts in England or elsewhere has been sought on such pests as moth-borer or shot-borer. Beyond isolated accounts of this nature there is little recorded of the insect pests. Such writers as Guilding, Schomburgh, and Gosse added to our knowledge and Guilding's work in the early part of the century seems to have been the nearest approach to a comprehensive treatment of local insect pests. Little else can be found of a systematic nature; there is no general information collected together as to the destruction due to injurious organisms and the problem of dealing with insect pests methodically and thoroughly has till recently seldom been thought of in these Colonies. This is on a par with what has occurred in other parts of the British Empire and of the world in general: almost all organized attempts to deal scientifically with this problem have been made in recent years, and insect control is now receiving attention in the greater part of the civilised world. What has been done in America, in France, in Germany and in other foreign countries needs equally to be done for every important British Colony and there is reason to hope that the problem will shortly be widely dealt with.

In the West Indies, as elsewhere, there is room for much work, and above all for a more generally diffused knowledge of insects and their ways of working. So long as the phenomena of insect life are almost unknown to the majority of people, so long will any progress in the adoption of remedies be very slow. There should be a general interest in the phenomena of nature, and the elementary facts of insect life and of the everyday workings of the animal and plant world should at least be generally familiar.

Prosperity has perhaps been the greatest enemy to the advance of knowledge concerning local insect pests; the occasional excessive abundance of an injurious insect would pass and scarcely leave its mark in the old days of high prices and greater wealth, nor would regular heavy loss probably have been perceived by the majority of planters in those times. On the other hand low prices and great depression are very unfavourable, as people look rather to the greater evil, and neglect the lesser. The greatest advance in the knowledge of West Indian sugar-cane pests was made when, after years of prosperity, the prices went down, profits were diminished and the struggle commenced to become acute. The loss due to disease became of importance and, with the appearance of hitherto unnoticed pests, combined with the prospect of partial failure under harder conditions, the investigations into cane diseases became more extensive and were followed with keener interest. So it was that the last decade of the nineteenth century saw increased attention given to scientific work in the West Indies on this subject, and though little was done beyond the study of cane-diseases, there was a great advance on the results of former years.

It is just when the moderate profit of the agriculturist is threatened with destruction by insect pests that a steady interest is likely to be taken in entomology and it is this, not the spasmodic scares and alarms, which lead to a general method of insect control being intelligently followed. A revival of interest in insects commonly accompanies an actual or potential outbreak of some striking pest, but this is again followed by a deeper apathy. Elsewhere, where profits are moderate but steady, the farmer knows that the five or ten per cent. loss that follows the insect attack means the loss of his profit and so his interest in 'bugs' is steady, lasting and productive of good work. Without the sustained interest and co-operation of those actually concerned in agriculture little progress in applied entomology is possible, and no thorough steps can be taken to check loss from insect pests in general.

ECONOMIC ENTOMOLOGY.

Economic entomology again is a growth of the latter half of the nineteenth century and has arisen largely as the need for it became evident. Entomologists have been busy collecting and classifying the great variety of new insects found in almost all parts of the world; and while there has been a wider interest in the biology of the insects, their life histories, habits and distribution, economically important insects did not receive a special share of attention until the urgent necessity for it arose, and the circumstances then demanded at once a large amount of detailed work for immediate application. Consequently there has not been any great opportunity for arriving at the general laws which underlie the subject; most economic entomologists have to deal with one pest after another as they come, having regard only to that one insect and its local occurrence. Few get time to take breath and see whither the whole science is advancing or to seek for the principles that lie hidden behind the mass of detailed work. A proportion of the knowledge gained was ephemeral, and has since been superseded and each entomologist often has to repeat the investigations of his fellow workers, testing and applying them under various local circumstances. Thus special attention has to be given chiefly to the pests that arise in his immediate neighbourhood and what time remains is often given to diffusing a knowledge of his science or to enlarging the records of the fauna of his province.

Of the many workers who are able to devote themselves to whatever branch attracts them most, few choose the economic side, and had a fair share of attention been given to the principles of economic entomology much more would have been learnt than the hard-worked official can now undertake. The study of entomology embraces a vast domain, and while the whole science is slowly progressing the economic part is relatively far behind. So it is that applied entomology has continued largely on its original lines; and new paths are rarely struck out or sufficiently studied.

The problem of insect control on a large scale has not as yet received the attention it deserves: the very valuable work

of the United States entomologists forms a conspicuous exception and the most important contributions to this subject are due to their labours. Other countries have added slowly and there are evidences of a larger importance being attached to this problem. Many fundamental facts, such as the influence on insect life of the introduction of new birds or insects have been little studied, and though the application of this method has occasioned great expectations during recent years owing to the success that attended its first adoption, yet two leading American entomologists have recently expressed the opinion that little can be gained from pursuing it.* The matter is evidently but little understood and it is not known why such introductions should not be successfully carried out.

Again, we are not in a position to define the causes that lead to an outbreak of insect attack; we should be able to say why a particular pest suddenly becomes abundant, and why for instance insect attacks in the West Indies seem to have been far more extensive in 1901 than in 1900. Such phenomena may some day be forecasted and guarded against, as hurricanes now are, when our knowledge of the laws that govern them attains to greater completeness.

Enough has been said to show the difficulties that beset this subject, on the one hand that of stimulating general interest in it sufficient to carry through any comprehensive steps and on the other those that arise from partial knowledge and incompletely understood laws. The time should soon come when some measures at least may be adopted for the West Indies. The conclusions drawn from the work of other countries are capable of application to local needs and circumstances, and until some action is taken the loss now sustained from insect pests cannot be checked and may even grow to an extent never experienced before. Intensive cultivation often brings diseases in its train but the West Indies do not seem to have experienced any outbreaks comparable in their intensity with those that lay waste large areas elsewhere. Insects have to be reckoned with by successful planters in the present days of competition, just as surely as do other bad conditions, and the spirit that leads farmers in the United States and elsewhere to spend thousands of dollars in fighting losses from insects should be met by a similar spirit on the part of the West Indian planter.

In these pages an attempt is made to set forth a comprehensive scheme whereby the losses due to insect pests may be minimized. Such a scheme may be of slow realization but this paper will serve a useful purpose if it shows on what general lines the problem may be attacked and what measures can usefully be discussed in the future.

WEST INDIAN CONDITIONS.

Before considering in detail how we may meet this problem

* C. P. Lounsbury, *Report of Entomologist, Cape Colony* 1900.

in the West Indies, we may briefly glance at the conditions which underlie it.

A favourable condition is found in the fact that the majority of these Colonies are islands, excepting British Guiana and British Honduras, surrounded by sea and more or less isolated from the mainland. This at least renders the conditions more stable; any efforts that may be made will only slowly be affected by the introduction of new forms of life. The fauna can be studied and the exact conditions determined for each Colony without the disturbing factor of irruptions of new pests. Also, as we shall see, we can control the introduction under commerce of new insects; quarantine regulations will be far less irksome and exacting in their operation. Again, some of these Colonies have but one or at most two staple crops; this is a very great advantage as it not only facilitates the work but ensures the greatest possible uniformity of interests and efforts on the part of those interested. Further, the gradual adoption of portions of a comprehensive scheme are rendered easier. Were there necessity for the adoption of each step simultaneously throughout the entire West Indies, there would be longer delays in securing a unanimity of opinion. As it is, the different islands can adopt such means as seem best, and the remainder can then judge of their working before enforcing them universally. Thus the natural divisions of these Colonies may prove of benefit and may be counted among the few natural advantages in such a scheme.

A second is probably the fact that West Indian crops differ largely from those grown in temperate climates. In spite of other disadvantages, this is yet a favourable feature since there is less fear of the introduction of virulent pests through the principal trade routes to England, Canada, or the United States. Jamaica, Trinidad and British Guiana are exposed to danger from their Central or South American commerce, and for all the Colonies there is this fear, but it is less imminent for the West Indies generally than it would be under temperate conditions of climate or agriculture.

On the other hand there are several unfavourable circumstances. Not the least of these is the fact that the low value of some staple crops and the general depressed financial condition does not encourage the adoption of remedial measures. Especially is this so where there is a high proportion of absentee-owners, who may not understand the necessity for such measures and so disapprove of them. In the present state of the sugar-cane cultivation the knowledge that the amount needed for remedial measures can but ill be spared is a strong incentive to a policy of 'masterly inactivity,' and no experimental proof of the value of a remedy may be strong enough to bring conviction where such a consideration is operating very powerfully. There is also the fear of the same policy being pursued from very different motives in other cases, where for instance large profits are being obtained from such permanent crops as cacao. If an estate bears well and yields high profits under a certain course of treatment, there is a considerable inducement not to embark

on a new line of treatment or not to interfere with the old policy, however great may be danger for the future Success in the past has too often been accompanied by carelessness and the golden days of prosperity have been allowed to pass by to be followed by the black times of depression that might probably have been averted by forethought in the preceding period. A portion of the large profits made in the old days of West Indian sugar would have sufficed to stamp out such a pest as moth borer, but we have no evidence of any general action. There is as great a necessity for the adoption of reasonable precautions in the times of prosperity as when the struggle is keen with the additional incentive of no lack of means to carry out that treatment.

Another unfavourable feature is the profusion of wild plants so frequently found in and around cultivated land. Mr. Marlatt in his account of California* notes as a distinctly favourable feature that all cultivated, i.e. irrigated, land is isolated, the orchards being surrounded on all sides by barren dry land where plant life cannot abound. This is not so in the West Indies, and the work of treating such pests as scale insects is largely added to by the fact that native trees and shrubs harbour the same pests and constantly communicate them to cultivated plants.

Thus, the forest land that occupies so much of St. Lucia and Dominica may be producing a supply of injurious insects which wander into the cultivated areas, and the mere clearing of such land exposes the cultivation to attacks from the insects which have been deprived of their natural food and habitat. This danger hardly exists in Barbados where so much is under cultivation but it is probably present in all the other Colonies, even in St. Kitts where the grasshoppers descend from the hills to eat the young canes and green dressings. Constant vigilance alone will meet this danger and it may certainly be reckoned among the features inimical to successful insect control.

A further unfavourable feature is the rather low degree of intelligence and want of aptitude of the average West Indian negro, to whom must be entrusted the performance of actual measures.† He is not as a rule capable of using even the simplest new implement save under strict supervision: where in England the ordinary labourer could be entrusted with a spraying machine and shown its use, few estate negroes can be taught the use of novel implements or trusted to carry out unfamiliar work. Very generally the simplest tools alone are used in the cultivation of the land and the difficulty of introducing new methods or unfamiliar tools must be taken into account. Spraying or other new work cannot be easily undertaken on a large scale under these circumstances, and the small capabilities of the labouring classes must for a time at least prove a hindrance to some features of this work.

Finally any general measures must be slow; the pests to

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* "Insect control in California," C. L. Marlatt, *Yearbook of the Department of Agriculture, United States*, 1896, p. 217.

† This refers only to the Lesser Antilles. I have no experience of the larger Colonies.

be dealt with are often new to science and there is little recorded about them: little can be learnt from the detailed work of other countries, and we can only apply such general methods as will fit the strange conditions. This is a more real difficulty than would appear at first sight and may fitly conclude this sketch of the conditions under which the problem of insect control has to be attacked. We may now pass to a consideration of the general lines and methods which are likely to give good results in the face of these conditions.

METHODS OF CONTROL.

There are five principal ways in which we may hope to attack this problem. They are:

(1) Measures to prevent the introduction of new diseases (such as Quarantine or the regulation of plant importation).

(2) The adoption of Preventive Measures.

(3) The adoption of Remedial Measures.

(4) The encouragement of useful native birds and other organisms.

(5) The introduction of new insectivorous birds, insects, etc., and the regulation of the importation of new animals.

Each of these has a distinct place in a general scheme of insect control; firstly, there is the question of limiting our pests by preventing the introduction of new ones; the necessity for this is evident. Secondly, there are those general measures of precaution which are likely to avert insect attack from the various crops; evidently, it will be wise to take such precautions as are likely to preserve cultivated plants from attack by insect pests, and this forms an important feature of this scheme. Thirdly, there is the evident necessity of checking actual attacks, by destroying as far as possible such insects as are found to increase in great numbers. This is the backbone of all methods for insect control. Finally, there are two general methods of influencing the problem; one by encouraging all natural checks so that the actual work of combating insect attacks will be reduced automatically to a minimum; the other by safeguarding the whole scheme against failure following on the introduction of new organisms which might upset the balance of life. It will be convenient to discuss each in some detail in the above order.

REGULATION OF PLANT IMPORTS.

The necessity for some regulations over the import of plants has now been generally recognized and has resulted in the adoption of various measures by the majority of civilised nations. The recent occurrence of the Colorado beetle in England, due apparently to its chance importation by a vessel arriving at Tilbury docks, is an example of the way in which insect pests spread and there are many cases on record where

severe losses have followed the casual introduction of new insects.

In discussing the danger of importing insect pests to the United States, Dr. L. O. Howard says: 'We need only look at the already long list of prominent injurious insects to become at once aware of the fact that had a national quarantine been established long ago its saving to the country would have been enormous. For example, at the World's Colombian Exposition a somewhat elaborate collection of the injurious insects of the United States was exhibited by the Department of Agriculture. This exhibit was included under 602 numbers. Of these 602 numbers, 111 referred to imported species. Again the writer has drawn with great care a list of what may be termed the injurious insects of first class importance. This list was prepared upon the most rigid lines and every species not of prime importance was excluded. Seventy-three species remained, these are insects whose names and depredations are familiar to almost every farmer and fruit-grower. In fact, each of them almost annually causes a loss of hundreds of thousands of dollars. Of these 73 species, 30 are native to the United States. 37 species have undoubtedly been introduced from foreign countries, while 6 are of doubtful origin.'*

Of the different States, California has been prominent in dealing with this question. Dr. Howard says: 'The experience in California is an interesting one and its results should be appreciated. By the operations of a state law and by the co-operation of the common carriers of the State an inspection system has been carried on for a number of years, which, without doubt, has prevented the establishment of many species of injurious insects within the state boundaries. Every vessel containing suspected articles entering at the port of San Francisco is examined by the state officer, who has power to condemn or to order treated all plants, trees, nursery stock, or fruit consigned to persons living in California which in his judgement may need such condemnation or treatment.'†

Two years later, F. G. Havens gives his experience of the efficiency of this system in Riverside, California:—

'The work of insect pest control naturally divides itself into three parts, viz., inspection, eradication, and quarantine.

'The quarantine work is regarded as the most efficient part of the service. The pests kept out do no harm. In this part of the work is included the inspection of all nursery stock grown in the district, and the inspection and treatment of all nursery stock and fruit brought in; also, the inspection of fruit packing houses, and attention to all of the methods whereby insect pests might be carried from one locality to another orchard or locality. So efficient has this work been that no insect pests have been brought into Riverside and become established since the Horticultural commission was established; and this too in the face of the fact that in 1890, 1891 and 1892 more than 200

* Danger of importing insect pests. L. O. Howard. *Yearbook of the Department of Agriculture* United States, 1897, p. 529.
† Ibid. p. 531.

carloads of orange nursery stock were brought to this place from Florida and set out.'*

These accounts show of what value the system has been to the fruit growing interests of California, and there are many equally convincing accounts of the work done on these lines in the United States.

The subject has also been dealt with by Henry Tryon, the Entomologist in Queensland, who writes: 'One cannot afford to lose sight of the fact that it is to human intervention, to international commerce, and to ordinary trade relations, operating, it is true, in conjunction with such congenial natural conditions as are above alluded to, that a country is indebted for many of the forms of life that are most conspicuous in their presence. This is especially so as regards insects and above all of such as are injuriously related to the plants engaging the skill of either agriculturist or horticulturist and which not only impair—or even determine—the vitality of these plants, but are also harmful to the crops that they yield or to the manufactured products that in these originate.' †

Much more could be quoted to show the value set on this subject by entomologists in all parts of the world, but the above will serve as examples. Further information is contained in the *West Indian Bulletin*, Vol. I. pp. 133, 309 and 157.

Many instances can be quoted where there is now a very evident necessity for preventing the spread of insects both between these Colonies and from abroad. The experience of the past two years of the insect pests of the various staple crops has shown that there is probably no important crop either in the West Indies generally or in each Colony which is not exposed to danger in the future from the neglect of these precautions. Apart from the scale insects, which in themselves offer very striking evidence, there are other insect pests ready either to be diffused from Colony to Colony or to enter from the outside, and the facts derived from the study of the insects themselves point very strongly to the necessity of this work. This subject is too large to enter into in detail at this time, and probably every planter can from his own experience and knowledge find facts to bear out fully the above statements.

For the West Indies it will be necessary to distinguish in particular between imports from abroad and intercolonial trade. Owing to the fact that a large proportion of our imports from abroad are from England, Canada or the United States of America, where other climatic conditions, crops and pests are found, there is less fear of the introduction of virulent pests from abroad. Dangerous localities would be the Southern States, Central America or South America, where similar crops are grown and similar conditions prevail. There is an equal need of regulations to deal with intercolonial trade; the pests

* F. G. Havens, Insect Control in Riverside, California, *Department of Agriculture United States, Division of Entomology, Bull.*, 22, N.S. p. 83.

† Destructive insects liable of introduction to Queensland. H. Tryon. *The Queensland Agricultural Journal*, vol. 2. p. 30.

already found in each Colony should be restricted as far as possible since they are the ones most likely to become established in neighbouring localities.

The problem has elsewhere been dealt with in a variety of ways including the following:

(*a*) Power to destroy all plants or parts of plants found to be infested with disease, at the port of entry.

(*b*) Absolute prohibition of the importation of either a particular class of plant from any locality; or of any plants or parts of plants from a specified locality.

(*c*) Inspection of nurseries and all places whence plants are sold; with the issue of certificates of the absence of disease without which plants may not leave those places. (This is applicable only to intercolonial trade or to foreign countries where this regulation is in force.)

(*d*) Importation permitted, subject to:—

(1) Inspection on arrival.
(2) Fumigation on arrival.
(3) Quarantine on arrival.
(4) The production of a certificate from some specified officer at the port of shipment that no disease is prevalent there or to be found on those plants.

It will be convenient to glance shortly at each of these, and consider which is best fitted for local application.

Destruction of Infested Plants. This is evidently a general measure that might find a place in the statute book of every Colony. It enables prompt measures to be taken to prevent the introduction of any particular form of disease that is easily recognisable; its application is perhaps not very wide but it would serve a useful purpose, for instance against diseases of sweet potato. There are two beetles which infest the tubers of the sweet potato, one in Jamaica, and the other in Barbados and Antigua; evidently both of these are liable to be carried in sweet potatos and their presence is usually easily detected on inspection. Sweet potatos then would be examined and if found to harbour any beetles, would be at once destroyed. Similarly for any easily recognised forms of disease, such as bad attacks of scale insects; no action would then be required beyond the destruction of the whole consignment of plants.

Prohibition. This again is a useful general measure, already adopted in Jamaica, Montserrat and elsewhere. It enables any Colony to protect itself against well-known forms of disease, and as the plant diseases of these Colonies become better known, the application of this method will become far wider than it is now. If a serious pest is found on cacao or coffee in any Colony, all cacao or coffee-growing Colonies should quarantine that infested locality and so prevent the spread of the disease.

For instance, the importation of sweet potatos from Jamaica, Barbados, or Antigua could be prohibited in all other Colonies where either of the sweet potato pests did not

already occur, and there are many pests that could in this way be restricted. The usefulness of this measure naturally depends largely on a knowledge of the pests of these islands, and though this is as yet far from complete, there is room for a wide application of this method on our present knowledge alone.

Certificates. The matter has been dealt with in some countries by the issue of certificates of freedom from disease to nurseries by qualified inspectors without which no plants may be sold or sent out of the nursery. Evidently, this method could only be applied to trade between the West Indian Colonies, and would be inefficient under the conditions obtaining here at the present time. Botanic stations supply many young plants, and the nurseries are inspected at varying intervals, whilst every effort is made to keep them free of disease. But plants are sent from one Colony to another irrespective of the Botanic stations and it would be impossible to control this trade by any system of certificates.

Treatment of Imports. Under this regulation the importation of plants is permitted, subject to certain restrictions.

We have already discussed two methods (*a*) and (*b*) of dealing with the *known forms of disease likely to be introduced* and it is necessary to supplement this by some general method applicable to *every organism* which it is undesirable to introduce. There are many cases on record of insects, harmless in their native place, becoming virulently destructive when introduced to new conditions. Generally speaking, it is unwise to bring in any new form of life whatever, without some knowledge of the effect it is likely to produce, and the value of restricting the casual introduction of fresh insects or other organisms has been abundantly proved in America and other countries.

This may be effected by suitable restrictions on the importation of plants; of these the first (Inspection on arrival) is unsatisfactory and inefficient. No inspector can guarantee the absence of scale insects for instance; in addition, skilled inspectors are not available in the West Indies. The second (Fumigation on arrival) is likely to be more satisfactory. Jamaica has adopted it and good results have been recorded in Ceylon and Cape Colony.* All dangerous articles (living plants, parts of plants, cuttings, suckers, etc), are exposed to the fumes of hydrocyanic acid which destroys all insect life, including eggs, and does not injure the most delicate living plants. Evidently this is a thorough method, since no insect can be introduced on these plants; it would not be applicable to an insect that bored into the interior of say a sweet potato, but it does destroy every scale insect that may be on the fumigated articles.

Fumigation need only be applied to dangerous articles, and those would not include the various articles imported for food, such as bananas, pears, etc. From the returns obtained from the Custom houses a list can be drawn up of these

* C. P. Lounsbury: *Report of the Entomologist*, Cape Colony, 1899, p. 9.

dangerous articles, and it is evident that there would be little hindrance to trade. The work is simple and easy, involves no highly skilled labour, and will probably be found to be the best method for local circumstances.

The third restriction (Quarantine) is a clumsy method, not capable of easy application. Plants on arrival are grown in an isolated spot apart from cultivated lands and are visited periodically by an inspector who declares when they are free of disease and may be planted out. This method involves the services of an inspector and a quarantine ground, and is not a perfectly safe one. The last restriction (Certificates) has a limited application in the case of plants passing through a Botanic station or obtained direct from a Botanic station. Such plants are allowed entrance on the production of a certificate from the Curator of the Botanic station at the port of shipment that the plants have been fumigated immediately before shipment. It may be found useful to adopt it as a supplementary measure but evidently it has not a sufficiently wide application.

In conclusion, it appears evident that the importation of new diseases can be avoided by adopting three measures:– Infested articles will be destroyed on arrival, dangerous plants will be prohibited or dangerous localities quarantined, and all imports liable to be the means of introducing any live insects will be fumigated with hydrocyanic acid. The first two of these will enable every Colony to protect itself from *specific diseases known to be easily introduced*, and the third will be sufficient to *keep out all others*. These measures are not difficult to carry out, involve little hindrance to trade, and probably include those found to be most efficient in other parts of the world. Their adoption is abundantly justified by the very great importance attached to this problem both in other countries and the West Indies themselves. On general principles alone it is evident that there is a constant danger from imported pests, and the evidence derived from the study of the insect pests of the West Indies shows that this danger is a real one that menaces every important crop in these Colonies. Had some regulations been in force before this, many of the most destructive scale insects and other pests would probably never have been found here. This subject deserves fuller treatment, there being a considerable mass of evidence derived directly from local insect pests and conditions, which would be out of place here; and we may proceed to the second general method of insect control.

PREVENTIVE MEASURES.

The second general method of insect control is the adoption of suitable preventive measures. Prevention, we know, is better than cure and costs much less; but the drawback to preventive measures lies in the fact that when they are successful, there is little or no evidence of their value. When an insect attack is predicted and preventive measures are recommended and adopted, there is, if they have proved successful, no evidence of the loss likely to have been

caused by the pest, and the necessity for applying these measures does not become apparent to those who carry them out. Preventive measures are usually put into practice after an outbreak of disease which renders their value patent to all and so lose their opportunity of being most efficient. The adoption of such measures *before an attack* demands a great feeling of confidence in those responsible for the recommendation and such a feeling is of slow growth and of somewhat rare occurrence.

Preventive measures are of great importance at the present time in the West Indies. As has been recently * pointed out, the sugar-cane weevil can probably be fought only by the general adoption of certain preventive measures. In St. Lucia and Dominica there is at present the danger of new pests arising owing to the clearing of large areas of forest land.† Preventive measures in these cases consist mainly in very great vigilance, and the necessity for such vigilance cannot easily be demonstrated in every case. Yet there is reason to believe that had this vigilance been exercised in the past, such pests as the cacao beetle of Grenada would not have become established. In all places where cultivation is taking the place of forest land, such a measure may be of the greatest importance to that Colony. Amongst the more definite preventive measures the following deserve mention:—

Favourable Conditions. A crop should only be planted in a favourable climate and locality; this is of great importance in planting up newly cleared land. Insect disease of all kinds is more prevalent among plants that are not fully suited to their surrounding circumstances. A plant such as the lime, which requires a certain amount of moisture, should not be grown where such a degree of moisture cannot always be obtained since it will then be liable to the attacks of scale insects. If two plants, primarily of equal vigour, are planted out, one in favourable, the other in unfavourable conditions, the latter not only suffers more from insect attacks but is more liable to it, especially in the case of scale insects. A notable case of this has been found in the Arabian coffee which appears to suffer far more in low altitudes from the attack of leaf-miner, than in high altitudes. In planting coffee this should be taken into account and it is reasonable to regard such a general precaution in the light of a preventive measure.

Maintenance of Vigour. Plants should be maintained at the highest pitch of vigour to secure them from disease. There may be a temptation to obtain an unduly large crop at the expense temporarily of the vigour of the plant, but this is likely, sooner or later, to be discounted by the attacks of insect pests. Naturally, this applies chiefly to permanent crops such as cacao, limes, etc. To maintain a plant free from

* 'Lectures to Planters,' Barbados, Lecture vi, October, 1901.
† Vide ante p. 323.

disease, it is necessary to preserve its vigour to the utmost, securing such a measure of crop as will not impair that vigour. Too heavy cropping probably reacts in many ways on the plant, besides rendering it more liable to insect disease, and it will be a wise policy to care first for the general health of the plant and not consider only its present yield.

Clean Culture. Clean culture is another matter that may be classed under this head. The presence among cultivated land of weeds and useless plants has often been found to be an incentive to insect attack. Equally so is the practice of leaving decaying parts of plants, such as empty cacao pods, or rotting timber. When an area of land has been placed under some crop, all unnecessary plants or vegetable matter should be removed. It is not a long step from the rotting cacao pod to the live one, and there is no advantage in tempting insect attack in this way. Thus it has been found that the 'thrips' that attacks cacao occurs on the wild guava and cashew, and has possibly come from those plants. The presence among the cacao of guava or cashew can then only be regarded as a danger, since the thrips finds a congenial breeding place among these plants and having overpopulated them attacks the cacao. It is advisable that all insect breeding places be removed as far as possible from cultivated land. The value of this recommendation is seldom easy to prove, but a fuller knowledge of insect life always points to danger in this direction.

Trap Crops. A preventive measure of occasional value is the use of trap-crops. In the case of moth-borer it is found that Indian corn is a favourite plant of this insect, and being of less value than cane, it is sometimes advantageous to plant corn among the young canes, not only to draw the pest from attacking the young canes but to enable the insects to be destroyed with the infested corn without appreciable loss. There are other ways in which this principle may be turned to account when the habits of our insects are better understood.

Rotation of Crops. Another preventive measure lies in the rotation of crops. When the potato weevil attacks sweet potatos, it is obviously wise not to provide that insect with its food plant for such a period as will starve it out and compel it to go elsewhere. Carried to its extreme limit this measure might be sufficient to exterminate many West Indian pests, since we have for example only to abandon the cultivation of cane, corn, etc., in such a place as Barbados (where wild plants are few and could also be destroyed) for say two years to starve out many destructive cane pests. Evidently this is too drastic a measure, but when it is practicable to substitute another crop for a sufficient interval without any great loss, it will be wise to do so when insect attack is excessive.

Modified Estate Practice. An insect pest may often be kept away by some change in the regular routine practice of cultivation. If we realise that insect pests adapt themselves to our system of cultivation, the value of this is more easily

recognised. Thus the sugar-cane weevil is fond of attacking the exposed ends of cane plants in the ground. The simple expedient of planting cane plants below the surface baffles the insect. This principle is probably capable of a wider application, but it is seldom realised that insects' habits are in very close relation with our agricultural practice. The keen struggle for food in the insect world probably compels the insects to seek out the weak spots in our agricultural practice and to take advantage of them. Many methods of averting insect attack depend on this principle and it is often valuable to consider whether some slight change in our established practice may not have an effect on our insect foes.

Destruction of Infested Plants. The last preventive measure is the destruction of badly infested plants which are beyond the power of remedial measures. An attack is often allowed to continue until there is no chance of saving the plants, and they then become the means of infecting neighbouring plants. This is especially so with regard to trees, such as the orange, which are infested with boring beetles; they may continue to bear fruit whilst in a hopeless condition of disease, and should certainly be cut down and burned to save other trees near by. This measure is capable of application to other crops, the destruction of one part of a field often securing the remainder from that form of attack.

Preventive measures as a whole depend more for their application by planters on a little general knowledge of the way in which insect pests attack plants than on any definite recommendations that can be made for each crop. Local conditions often determine their utility; in an advanced community they would be regarded as the common-sense of the subject, and as the basis of all treatment for insect pests.

Some points of general importance will be discussed towards the end of this paper after the consideration of remedial measures.

REMEDIAL MEASURES.

The third general method is the adoption of remedial measures. These are as a rule in the nature of special recommendations, based on the particular behaviour of each pest, and do not fall readily under general heads. For their application they depend on three things: their simplicity, bringing them within the scope of the West Indian labourer; their effectiveness, to deal thoroughly with the pest; and their relatively small cost. When these conditions are fulfilled, then adoption again depends on the view taken by the planter of the loss he is incurring, as also on his view of the increased yield that will follow the adoption of the remedy. The unfavourable conditions discussed on page 320 are of the greatest importance here, and the adoption of remedial measures will be largely a question of the severity of insect attacks and of the value to the planter of the experimental proof of the utility of those remedial measures.

Remedial measures fall roughly into three classes:

(*a*.) *Direct Methods*. Direct methods of attack with simple means that can be applied by the ordinary labourer. Such methods include the cutting out of the young canes attacked by moth borer, the collecting of moth borer eggs, the cutting out of the grubs of the cacao beetle, the collection by hand of the grasshoppers in St. Kitts, hand picking caterpillars on tobacco, and similar remedies. In some of these cases, the sharpness of West Indian negro boys and girls below the age of fifteen or sixteen renders them specially suited to this class of work, and the practicability of it depends largely on the available supply of this labour.

(*b*.) *Trapping and Baiting*. Methods of trapping or baiting. Such are the use of lights to trap moth borer or other night-flying insects, the use of baits for grasshoppers, and of trap logs for tree-boring beetles. They are usually simple in operation, demanding neither skilled labour nor special appliances.

(*c*.) *Use of Poisons*. The use of poisons, both stomach and contact: these differ in no important way from those used in other parts of the world and have the same general value. Their application in the West Indies is hindered by many circumstances. There is firstly, the incapability of the West Indian negro to understand all but a simple form of spraying machine or other device for applying poison. Secondly, there is the limited applicability of the remedies owing often to the small areas to be treated; a sprayer no larger than a knapsack machine is usually required and the more economical power-spraying outfits are not likely to find use in these Colonies. Where there is a large area of a valuable crop such as cacao or limes, the physical conditions of the land often render it useless to employ any but a knapsack machine. The difficulty of spraying any considerable area of cacao growing in rocky land with a high slope is very considerable, and the obstacles encountered in mere transport to or over an estate in some of the islands will discourage this form of treatment very considerably. There is also the difficulty of obtaining the poisons recommended for use on the machines necessary for their application. Both can be obtained from New York or other distant places, but the demand has so far been so slight that it is difficult to supply them except in one central locality such as Barbados. As the use of poisons becomes more general, and a demand is created, it should become possible to obtain these articles in each Colony, and this difficulty will be thus removed automatically by the action of planters themselves.

Before these remedies are generally adopted there must be a truer appreciation of their value and uses. Spraying with arsenical poison in isolated cases is, after all, only a temporary measure to meet a local need. It does not necessarily cause any general diminution in the numbers of the pests until such applications become universal and regular. So also for scale insects; even in California where the conditions are especially favourable, it is the expressed opinion of Mr. Marlatt that 'It may be stated of all

the washes or other methods, that the complete destruction of the scale is rarely if ever secured by their use, and is not indeed hoped for. Experience has shown that the best that can be done is to effect a practical elimination of the scale for the time being, and it is often necessary to repeat the treatment every year or two. In exceptional cases it may not be necessary to do this more than once in three years. All applications are therefore recognised to be as necessary and continuous a charge on the crop as is cultivation or irrigation.' *

This holds far more strongly here where any wayside plant or tree may harbour the same pests as attack our cultivated plants. Spraying or other applications of poison are part of the regular work, justified by the greater yield obtained when they are applied.

In considering the problem of insect control as a whole, remedial measures are of the first importance. The means of checking the important pests now found in the West Indies form the backbone of such a scheme, and though not capable of extensive treatment on general lines, constitute the dominant element in insect control at the present time. For every pest, remedies have to be found which are adapted to the habits of that insect, and success can only be obtained, not by general principles, but by measures carefully suited to the individual conditions of pest, crop and locality. Whilst a considerable mass of information has been obtained and remedies have been suggested for the more important pests, the adoption of these remedies has as yet not taken place generally. For the planter, these remedies are of prime importance, and while the welfare of the whole community both now and in the future calls for wider methods of treatment, to the individual it is of more importance to guard against the losses now incurred from insect pests. So much has been written elsewhere on the question of remedial measures, that we may perhaps leave the subject of direct remedies, without detracting from its greater importance. The adoption of these remedies must finally be left to individuals. The wider applications of comprehensive measures are more directly the objects of the scheme as laid down in these pages.

PROTECTION OF USEFUL BIRDS AND OTHER ANIMAL LIFE

The problem of insect control is largely influenced by the action of the checks provided by nature on the increase of insects. The most obvious check is that due to the bats, birds, lizards and other creatures which feed upon insects. There is also the less evident, though equally efficacious, check from the hosts of predaceous and parasitic insects which attack their fellows. All insects tend to increase very much and in nature have to maintain their position against such influences as climate, weather, variable food supply etc., and against their enemies. It is found that these factors tend to keep the num-

* C. L. Marlatt. Insect Control in California. *Yearbook of the Department of Agriculture, United States*, 1896, p. 227.

bers of any species within certain limits, though these are not always as narrow as we could wish. But when land is put under cultivation the even balance is disturbed, artificial conditions are established and maintained by man, and the influence of beneficial birds and other insect enemies becomes altered. Man then has to fight, not only the number of injurious insects that would be found under natural conditions but also the increase due to the conditions he creates. Direct artificial checks then become necessary, but these may be reduced to a minimum by affording every encouragement to natural checks.

It is impossible to avoid creating artificial and unnatural conditions in cultivated land, and man can only attempt to render these as favourable as possible to the maintenance of a natural balance of life. In order to effect this, every insect-destroying creature should be encouraged, and its increase assisted as far as is found possible. It is frequently found that man himself, in shooting or trapping birds or by destroying their nests, is doing much to destroy that animal life which is of so much value to him and such practices may be more efficacious in driving away bird life than the artificial conditions which attend cultivation. Where birds, lizards, toads, etc., are allowed to live unmolested they soon accustom themselves to altered conditions, due very probably by the abundant supply of insect food found in cultivated land. In the West Indies, many birds are probably entirely insectivorous and many more are partly so. Few are harmful either to cultivated plants or to other birds, and it is as a rule easier to observe the injury such birds cause than to see their constant destruction of injurious insects. Native birds are protected under 'Wild Birds' Protection Ordinances' in some West Indian Colonies at the present time and in every Colony good results would follow the enforcement of an Ordinance similar to those of British Guiana,* St. Lucia,† and Grenada.‡ It would probably be wise to protect all birds, some completely, others partially. Almost all are of far greater value agriculturally than as either food or sport, and when any bird is found to have greater injurious than beneficial effect, the protection may be removed and its increase checked.

In addition to the birds, there are bats, lizards and toads, which need encouragement if not protection. Probably the best method of encouraging these consists in spreading a knowledge of their usefulness, and, in the case of the two latter, checking their enemy the mungoose. The mungoose was introduced to Jamaica in 1872 to destroy the rats which injured the canes. It did valuable work in killing rats, and was then driven to feeding upon ground birds, birds' eggs, lizards and toads. The destruction of the latter removed a most efficacious check on injurious insects and these appear to have multiplied and become increasingly destructive. This occurred not only in Jamaica, but in Grenada, St. Vincent,

* Ordinance No. 6 of 1877.
† Ordinance No. 72 of 1885.
‡ Ordinance No. 4 of 1891.

Barbados, Antigua, and St. Kitts, after the introduction of the mungoose. The condition of Montserrat and Dominica at the present time, where the mungoose has not been introduced, is a great contrast to the condition of the preceding islands, from the point of view of insect attacks, and there is good reason to believe that this is due largely, if not wholly, to the fact that mungoose is absent from the two latter. The mungoose as a rat destroyer is of value but its excessive increase, with the diminution of its proper food, leads to it becoming a pest itself by the destruction it causes amongst beneficial animal life. Under these circumstances we may usefully consider whether it would not be possible to take steps to check the numbers of this animal. There are two ways in which this might be brought about, first by offering a bounty for every mungoose killed, secondly by a general effort on the part of every island to destroy as large a number as possible. The first is of questionable value. J. S. Palmer in this connection says: 'Bounties have not resulted in the extermination of a single species in the United States and have failed even in the island of Bermuda which has an area of less than twenty square miles.'* Though a bounty may not bring about the extermination of mungoose, it may yet prove a sufficient check on its increase, which is the result aimed at. Probably good results can be obtained by general action on the part of all planters and it may be remembered that it is not the total destruction as much as the effective checking of the mungoose which is desired. As a constituent of the fauna, not increasing beyond reasonable limits, the mungoose will be of value as a check on the rats and there is reason to hope that some efforts to limit the numbers of this animal may hasten the restoration of the balance of life, which is said to be taking place now in Jamaica.†

In addition to the above useful animals, there are the hosts of predaceous and parasitic insects of whose work it is difficult to form any conception. Little can be done to encourage these beyond taking reasonable precautions that our preventive or remedial measures do not destroy them and spreading such a knowledge of them as will prevent their destruction through ignorance, as pests.

The question of the encouragement of useful organisms revolves itself into (1) Wild Birds' Protection Ordinances, (2) Care and encouragement of all bats, lizards, toads and beneficial insects, and (3) Any measures that may be possible in each Colony to check the mungoose or prevent its entrance. In no way shall we probably more easily influence our insect pests with profit not only in the present but in the future.

THE INTRODUCTION OF NEW ANIMAL LIFE.

The last general method of insect control consists in the introduction from abroad of useful birds, insects or other

* J. S. Palmer. Extermination of Noxious Animals by Bounties, *Yearbook of the Department of Agriculture, United States*, 1896 page 68.

† J. S. Palmer. The Danger of Introducing Noxious Animals and Birds. *Yearbook of the Department of Agriculture, United States*, 1898, page 93.

creatures. In places where there is already an abundance of native useful birds, the introduction of new ones is of questionable value, as the overwhelming number may destroy too large a number of beneficial insects or may upset the whole balance of life, driving formerly useful birds to find new food and become destructive. But in cases where beneficial birds, etc., are obviously lacking or have been too largely destroyed, and when special circumstances demand it, we may usefully supplement the native insectivorous animals by the introduction of others. In considering the advantages likely to be derived from the introduction of a new organism, there are three factors to be taken into account, namely the character of the organism introduced and the changes it may undergo in its new surroundings, the nature and origin of the pest we wish to combat and the composition and relationships of the fauna as already established. Bearing in mind these three, we may consider in what cases it would be advisable to attempt the introduction of new forms of life. Probably any attempts to establish such birds as the Barbados black-bird in the sugar growing islands will be useful, and it may be possible to find other instances where birds can be usefully spread within the West Indies, in addition to any it may be thought desirable to introduce from abroad. It will also be possible to introduce predaceous or parasitic insects, with a view to the extermination of particular pests and possibly this may become an important factor in the future of insect control in these Colonies. It is at present impossible to deal thoroughly with this point; there are many cases in which we can turn it to advantage in the future when further knowledge has been gained and when the more immediately necessary steps in insect control have been taken.

The problem of utilising useful birds and insects has received attention in all parts of the world and the value of the introduction of ladybird beetles reached such a height that Mr. Lounsbury the entomologist at Cape Colony wrote in 1898: 'It is not out of place to remark here that that part of the study of economic entomology which concerns the relations between insect pests and the forces which tend to their suppression is yet in its infancy and with a great future before it; through the knowledge being gradually acquired all over the world by a multitude of workers, the time is coming, I venture to predict when a systematised exchange of the natural enemies of insect pests will be possible and practicable and immensely to the advantage of agriculturists.*' In the United States in particular this problem first received attention and careful study. Such remarkable success as attended the introduction of the beetle *Vedalia* into California occurred side by side with partial or total failure. The subject cannot yet be regarded as settled; further light is required upon the conditions of insect life and the interreaction of the different organisms upon the fauna. The subject may claim especial importance in the West Indies

* C. P. Lounsbury. Report of the Entomologist, Cape of Good Hope, 1898.

where the fauna is in most cases isolated and constant, besides being often more limited, and there would be a greater chance of the matter being based on actual facts.

There is one other aspect of this question: that is, the regulation of animal importation from other countries or neighbouring Colonies. Montserrat and Dominica are protected in this way against the mungoose, and had such regulations been in force in 1872 the mungoose might never have been brought to Jamaica or the West Indies generally. Equally there is a danger of the introduction of birds, which might prove the reverse of useful in their new locality under different circumstances. It would probably be wise to restrict the importation of all birds or other animals from abroad, making it subject to permission from expert authority. This course has been adopted elsewhere with good effect, and in the United States the Lacey Act makes all such importations subject to permission from the United States Department of Agriculture.* Considerable importance is attached to this in the United States, and though the necessity for it may not be evident in the West Indies at the present time, its adoption may be the means of checking the introduction of undesirable animals, which would otherwise become of importance in the future. It forms a distinct part of any scheme of insect control, and in view of the ease with which it can be carried out should be adopted in common with other regulations that bear on this question.

We have now briefly considered the place in this scheme of the introduction of useful organisms. Much good may come from the careful application of this method when local conditions and pests are better known, and in the meantime chance introductions of any new organisms may be restricted so that all undesirable additions to the West Indian fauna are kept out. This portion of the scheme is not at present of the first importance; it occupies a definite place in a complete general method of insect control and so has to be dealt with here; but, beyond the checking of promiscuous bird or animal introduction it has at present less practical bearing than the previous portions.

VALUE OF LEGISLATION.

The methods of insect control have now been discussed and we may proceed to consider how far legislation is necessary or desirable to ensure the adoption of these measures. The subject divides itself naturally into two parts, the first comprising all that deals with the broad general measures which are rather the concern of the whole community than of the individual, the second dealing with those measures which must ultimately be the work of individual planters.

We may include in the first part:

(1.) Regulation of plant imports, quarantine, etc.
(2.) Protection of useful birds and other animals.
(3.) Regulation of the importation of animals.

* Digest of Game Laws for 1901. *Department of Agriculture, United States. Division of Biological Survey. Bull.* No. 16, p. 71.

Evidently these must be the subject of legislation, or their success is liable to be far from complete. If left to individuals they will be ignored and unheeded, their action being then naturally imperfect. The first only is likely to have any direct bearing on the actions of individuals, and any inconvenience that may arise from the enforcement of the fumigation of plant imports can be reduced to a minimum. Few people probably will be found to oppose these measures, which need only to be generally understood to find acceptance. Their working though perhaps almost imperceptible in immediate results, may yet be of the greatest importance to agriculture now and in the future. Measures that fall within our second division include all the actions to be taken by individual planters and others to check insect pests. The simplest case is to be found when a pest attacks the whole area of the staple crop of any Colony and a port on only of the planters adopt successful measures against it. Their efforts are then to some extent neutralized by the neglect of the remainder to carry out the same precautions, and it would be to the advantage of every one to enforce the general adoption of useful measures. Probably in most cases necessity will decide how far this principle is to be carried. The time may come when every insect attack will be dealt with immediately, either voluntarily or under compulsion, not only with a view to the particular crop attacked but with respect to neighbouring crops and to the complete checking of all outbreaks in the future. Before this is possible we must know all our pests, and experiment with the best methods of treatment. The possibilities of invoking legislation to deal with widespread attacks are now limited to the most prominent diseases of sugar-cane, sweet potato, cacao, limes, plantains, etc.

As further knowledge is gained, and there is a wider appreciation of the value of remedies, all serious insect attacks will be to some extent under control; treatment will be possible for all, and every planter having an attack on his crops will have to face the responsibility of dealing with the pest, or carelessly leaving it to do its worst on his land and infest his neighbour's after.

In every community there will be a diversity of opinion as to the value of the methods proposed and often when public opinion is strongly in favour of such measures legislation is invoked to ensure their universal adoption. Any scheme of compulsion necessarily follows public opinion and it is only with the approval of the majority that such measures can be carried out. Whilst it is probable, if not inevitable, that this problem must sooner or later become the subject of general legislation, the time is apparently not yet come for the wholesale adoption of a comprehensive scheme, and in all parts of the world the matter has reached various stages of development. Circumstances will render the necessity for different portions of this scheme obvious to all after longer or shorter periods in each Colony, and it will be of interest to consider what has been done in more advanced communities in other parts of the world. Measures regulating plant importation are the most general at the present time and it is to be hoped that the time is not far off when these Colonies will not be behind in this

respect. In no other way has the importation of diseases been successfully checked, and it has been found impossible to leave it to the discretion of every person to carry out these precautions. The failure of one individual may undo the work of all the remainder and such individuals are found in every community. Almost all highly civilised countries have regulations of some nature, *even if only directed against such pests as San Jose Scale or Japanese Peach Scale. The more important British Colonies have taken the matter in hand at one time or another. In the light of these facts and of the ease with which such precautions can be adopted in these Colonies, it is hoped that the necessity for them may soon be generally recognized.

For preventive and remedial measures there is by no means such a unanimous feeling regarding the value of compulsory measures. In cases of urgency, as when a widespread and devastating disease appears throughout a whole district, there would probably be little difficulty in securing the mass of public opinion in favour of compulsory treatment. The ordinance recently passed in Grenada † is an instance of such legislation; this allows for the entry into all lands of inspectors 'for the purpose of searching for and examining into any insect or fungus or any diseased tree, plant or vegetable.' On the report of such inspector the Governor may authorize the Chief Inspector to direct the occupier or owner to take the necessary steps for the destruction of such insect or fungus, etc. This ordinance also provides for the complete destruction of all infested plants and allows for compensation in cases where healthy trees, plants or vegetables are destroyed to prevent the increase or spread of disease in or into lands not belonging to the owner of the land on which such healthy trees, etc., are. It comes into operation on a date to be fixed by the Governor by proclamation, and provides thoroughly for compulsory quarantine, preventive and remedial measures. Evidently it gives great scope for the universal adoption of measures which might otherwise fail for want of co-operation and appears wide enough to be adapted to the majority of cases likely to arise.

In California there is a complete system of insect control described thus by Mr. C. L. Marlatt ‡: 'Each county has or may have, on petition of fruit growers, county horticultural commissioners, who are practically official entomologists, and have charge of all matters relating to injurious insects, both as to quarantining against their introduction and their eradication. These commissioners either do their own inspecting or are empowered to employ local inspectors. The local inspectors are supposed to be familiar with the common scale insects and experienced in the application of remedies and they make, at sufficiently frequent intervals, what is practically

* *Department of Agriculture, United States, Division of Entomology, Circular No. 41.*

† Ordinance No. 17 of 1900, Grenada.

‡ Insect Control in California. *Yearbook of the Department of Agriculture, United States*, 1898. p. 218.

a tree to tree inspection, and are empowered to enter all premises and enforce action. The result is that the presence of injurious scale or other insects is commonly detected at the very outset and remedial measures are promptly instituted. . . . Work is therefore in the main, not remedial but preventive, and in going through the orchards of citrus or other fruits in California one is usually impressed with the almost complete freedom from insect pests.' In these cases, unity of interest and imminent danger leads the whole community to recognise the necessity for some measures, and there are opportunities for this class of legislation in many West Indian localities at the present time. In practice, every estate should be treated on these lines, insect pests being systematically subdued, and in the majority of cases there is no reason why this course should not be adopted at the present time. Then, when the majority of estates are being so treated, it is but a small step to invoke legislation to make such measures perfectly successful by compelling every planter to fall into line and adopt the same treatment.

Many more instances can be quoted where preventive or remedial measures are enforced by law and the whole case is very similar to the laws which check the spread of infectious disease amongst man or domestic animals. A case of serious widespread disease arising in a valuable crop will be the best argument in favour of this class of legislation and the needs of the hour will then do what could not otherwise be effected with years of work. In the case of such familiar diseases as moth borer in sugar-cane, a great increase in the destruction caused by it may do much, but this is unlikely to occur. It is believed that universal treatment of this pest throughout any one Colony for say two years would prove sufficiently effective to convince all of the value of the compulsory adoption of these remedies, and this applies to other West Indian insect pests.

The protection of useful birds has been generally recognised as a fit subject for legislation, and every Colony could usefully adopt an ordinance to effect this. Against the general reduction in the number of birds, consequent on cultivation, little can be done, but it is at least possible to prevent the wanton destruction of birds or their nests, and few people would be found to oppose a reasonable 'Wild Birds' Protection Ordinance.'

Finally, there remains the question of regulations on the import of new forms of animal life. These are abundantly justified in view of the future of these Colonies, and the experience of the past has shown that though they may not appear to be of immediate value at any particular time, yet they have a great value as a distinct measure of precaution. It would be necessary only to forbid the introduction of any live animal without a permit from the Department of Agriculture or some other authority. Domestic animals, including horses, mules, asses, oxen, sheep, goats, dogs, cats, fowls, turkeys, ducks, geese, guinea fowls, etc., would be exempt, and this might include cage birds and rabbits, as well as other pet animals on the condition of their being kept in confinement.

This would cause only occasional inconvenience, by no means commensurate with the immense harm that at times follows the chance introduction of birds or other creatures.

In the United States, this matter has received full attention as the following quotations will show *:

'The examples already cited show the danger of introducing exotic species on large islands, particularly on those far distant from continents where the fauna is necessarily limited, and predatory species practically absent. In such places, introduced species are almost sure to increase very rapidly. The experience of New Zealand indicates the necessity of exercising unusual care in introducing birds and mammals into the islands recently acquired by the United States.' (Puerto Rico, Hawaiian Islands, Phillipines, etc.) .. ..
'Whatever may be the difference of opinion concerning the desirability of introducing exotic species, it will be generally admitted that some restriction should be placed in the importation of birds and mammals which may become injurious. Since it has been found necessary to restrict immigration and to have laws preventing the introduction of diseases dangerous to man or domesticated animals, is it not also important to prevent the introduction of any species which may cause incalculable harm. Experience with the English sparrow, the work of rabbits in Australia, and the mungoose in Jamaica, all these have abundantly shown the necessity of preventing the repetition of similar costly blunders in the future.'

Following on this in 1900, the United States Congress passed the Lacey Act of which section 2 reads thus †: –

'That it shall be unlawful for any person or persons to import into the United States any foreign wild animal or bird except under special permit from the United States Department of Agriculture, Provided, That nothing in this section shall restrict the importation of natural history specimens for museums and scientific collections or the importation of certain cage birds such as domesticated canaries, parrots, or such other species as the Secretary of Agriculture may designate. The importation of the mongoose, the so-called "flying foxes" or fruit bats, the English sparrow, the starling or such other birds or animals as the Secretary of Agriculture may from time to time declare injurious to the interest of agriculture or horticulture is hereby prohibited and such species upon arrival at any of the ports of the United States shall be destroyed or returned at the expense of the owner.'

Such an Ordinance might be wisely enforced in the West Indies without expense or inconvenience and the advantage in the future might be very great. It is an easy matter to keep out noxious animals, but as the mungoose has shown it is not easy if indeed possible to deal with them once they are in. As

* T. S. Palmer. Danger of Introducing Noxious Birds and Animals. *Yearbook of the Department of Agriculture, United States*, 1898—p. 106.

† Digest of Game Laws for 1901. *Department of Agriculture, United States, Division of Biological Survey, Bull.* 16, p. 71.

has already been stated, the English sparrow, now found in Bermuda, is a most undesirable bird to introduce, and such an Ordinance as the above would safeguard the West Indies against all but chance introductions. Probably there are many other undesirable birds or other animals which have an increasing chance of being introduced commercially; and this question can only be settled by legislation, without awaiting more striking examples than those furnished by the mungoose and the sparrow.

The value of legislation at present consists in enforcing quarantine and fumigation of imports, protection of wild birds and beneficial animals, prohibition of importation of new wild animals, and such Ordinances in each Colony as will render it possible to deal immediately and surely with virulent outbreaks of disease. There is little here likely to cause alarm or produce inconvenience, much of the legislation will be adapted to meet special emergencies and will enable general action to be taken in any Colony against an outbreak of disease. So far as the problem of insect control can be met by legislation, the Ordinances here suggested should be sufficient. For each Colony the legislation must be devised to meet local needs and fit local circumstances, and it is not possible in these pages to do more than suggest the main outlines of such work.

CONCLUSION.

It will be convenient to sum up the question of insect control in the West Indies as it appears at the present time. As a result of recent observations in the smaller islands, together with the information recorded in the larger Colonies during the past years, it is believed that a complete scheme of insect control can be drawn up, which will be applicable with small modifications to every Colony. The object of such a scheme is to check the increase and spread of all insect pests, to reduce to a minimum the present loss from insect attacks, and to safeguard these Colonies against such attacks in the future. As laid down in the preceding pages, the scheme consists of measures whereby.

(1) Every Colony is protected against the introduction of disease, either from abroad or from neighbouring Colonies, by means of quarantine and the fumigation of all dangerous imports.

(2) Preventive measures are recommended, and the necessity for their adoption by planters clearly pointed out, and if necessary they are enforced by law.

(3) Remedial measures for each pest, suited to the conditions under which that disease occurs, are devised, their value demonstrated, and their adoption urged on planters; when necessary in the interests of the whole community, their adoption is rendered compulsory.

(4) Useful birds and other animals are protected as far as can be done by pointing out their value in agriculture, and by checking their wanton destruction.

(5) Beneficial birds, insects or other animals are introduced from abroad when local circumstances enable this to be successfully done, and the haphazard introduction of undesirable animals is checked.

The above scheme embodies much that has been found of value in other parts of the world, and it is believed will probably prove sufficient to meet all eventualities. Insect control is successful only when vigorous preventive and remedial measures for the various pests are generally adopted by planters throughout each Colony, and when these are supplemented and safeguarded by legislation. A satisfactory solution of the problem is first to be found in the actions of individual planters and others engaged in agriculture; the sum of their work against their pests will then be thoroughly effective if safeguarded against new incursions of disease from without and against those disturbances in the balance of life which so frequently occur in cultivated areas. A great deal can be done either by direct preventive and remedial measures. or by those general measures which aim at maintaining a favourable balance of life with efficient natural checks on the increase of insects. Either of these alone will not fully meet the case; the maximum effect follows on the working of the two together, the one forming the complementary part of the other. A considerable amount of progress has been made in treatment of specific insect pests. The remedies for the majority of the present diseases lie at the planter's hand and need only to be carried out. So also some steps have been taken to encourage birds, to prevent the introduction of new forms of disease, and these lines of action need only to be continued throughout the whole of the West Indian Colonies to deal successfully with this side of the problem.

It is believed that the gradual adoption of the whole of this scheme by the general body of planters and by the government of any one Colony will lead to an immense diminution in the losses now sustained from insect attacks, and will reduce the danger of such loss to a minimum. The scheme is, in the present state of our knowledge, a tentative one, designed to be the foundation of successful work against insect pests. As knowledge grows and spreads, the problem will be more widely understood and appreciated and it may be possible to bring the efforts of each Colony into their place in a universal system of insect control from which the West Indies will derive benefit both now and in the future.

TREATMENT OF IMPORTED PLANTS AT JAMAICA.

The following 'Instructions for the Guidance of Officers of the Government Laboratory and Kingston Customs in regard to the manner in which imported Plants, Cuttings, etc., and

their coverings, shall be dealt with,' were published in the *Jamaica Gazette* (p. 14), January 9, 1902 :—

Immediately on the landing of any plants, cuttings or other articles, specified in the Governor's Proclamation of the 7th. September 1901, published in the Government Notice No .278, of the 10th. of that month in the *Jamaica Gazette* they shall be taken charge of by the Customs Officer who will give the Wharfinger or other party concerned, a receipt therefor, shewing the time and date of delivery.

The Customs Officer shall at once notify the Government Chemist, in writing, of the articles to be fumigated, stating the approximate dimensions thereof and obtain his instructions as to the time at, and place to, which they are to be forwarded for fumigation.

The Customs Officer will then forward the articles accordingly in charge of a Customs Escort who will remain in attendance during the process of the fumigation and afford, or provide such assistance and labour as the Government Chemist or his Officer-in-charge may require.

Immediately on receipt of the Articles the Government Chemist (or his Assistant) shall cause them to be fumigated in the manner and under the conditions prescribed by the Governor in Privy Council.

So soon as this has been done, and a memorandum shewing the time of receipt and delivery furnished to the Customs Escort, the Articles shall be taken charge of by the Escort and conveyed to the King's Warehouse or other place, as arranged by the Landing Waiter.

The greatest care must be taken by the Officer-in-charge of the King's Warehouse to keep plants, cuttings, &c., alive and in good condition.

All expenses of removing the articles to the Government Laboratory, and thence to the King's Warehouse, with any expenses necessarily incurred in keeping the articles in good condition, shall be met by the Importer, all such amounts being brought to account as King's Warehouse Fees as provided by the Customs Regulations on the subject.

Plants, cuttings, &c., should not be forwarded to the King's Warehouse in cases where Importers defray expenses of removal, labour, &c., (if any) at once, and at the same time arrange with the Customs Officer to take delivery of the articles immediately after fumigation. This provision will refer more particularly to the plants, &c., brought by passengers and imported through the parcel post, &c.

Officers of Customs and of the Laboratory are required to exercise strict economy in arranging for the transport of the plants, &c., and other expenses, so that the charge to the Importers may be as small as possible.

The above instructions look at first sight somewhat elaborate ; it is believed however that in actual practice they

will present no serious difficulties. They are probably unnecessary in all Colonies but Jamaica and Trinidad. In the case of the smaller islands the process of fumigating imports could be very much simplified, necessitating far less handling of the imported plants, and a very much shorter delay before they are delivered to their owners.

ANTS IN RELATION TO PLANTS.

It is commonly supposed in the West Indies that ants are injurious to cultivated plants. This belief appears to be due to the very general occurrence of some kinds of ants on fruit trees and other plants, rendering it almost impossible to pluck a twig from such infested trees without being inconvenienced by the ants. With the exception of the leaf-cutting ants parasol ants) found in Trinidad and South America, there are probably no kinds of ants directly injurious to plants in the West Indies. It is true that ants are found in enormous numbers on some plants, and that they frequently make nests at the roots, but it has never yet been definitely proved that they do any direct damage to the plants. The ants usually visit the tree for a particular purpose; some instances will be cited later. It should be borne in mind that these notes do not refer at all to the so-called 'wood ants' or 'white ants.' These destructive creatures are not true ants at all, but *termites*, a perfectly distinct group.

ANTS AND SCALE INSECTS.

Ants have frequently been recorded as being closely associated with insects known as 'green-fly' or Aphis (*Aphides*) visiting them to obtain their sweet secretion commonly spoken of as 'honey-dew.' Cases are on record where the ants undoubtedly cared for the green-fly, and made use of them in a manner comparable to man's treatment of such domestic animals as the cow.

In the West Indies green-fly are not so common as in many other localities and their place is taken by the scale insects and mealy-bugs. Many of these also excrete a sweet liquid which the ants appear to like. Some species, such as the common mealy-bug (*Dactylopius citri*) and the sugar-cane mealy-bug (*Dactylopius calceolariae*) have a characteristic mealy covering to which they owe their popular name. This covering the ants carry away, often completely stripping the insects.

Plants infested with scale insects or mealy-bugs frequently swarm with ants, which may be observed continually going from one insect to another in search of food. Sometimes the ants erect shelters over the scale insects. The leaves of a bread-fruit tree near the Head office of the Department, in Barbados, are infested with the common mealy-bug, the individuals being commonly found alongside the midrib. Over these the ants erect protective coverings, composed

apparently of earth and decayed vegetable matter. Sheltered in this way from enemies the mealy-bugs live in safety repaying the ants for their care by supplies of honey-dew. This mutual arrangement between the ants and the mealy-bugs may lead indirectly to injury to the plant, as the following quotation from a letter of Mr. Henry Tryon, the Government Entomologist of Queensland, reprinted in the *Agricultural Journal of the Cape of Good Hope*, Vol. XVIII, p. 519, indicates. Speaking of a *Dactylopius* which there infests pine-apples, he says: 'In the northern coast districts *Dactylopius* is more pernicious by reason of the attention bestowed upon it by ants. The mealy-bug as a rule congregates at the base of the fruit and between it and the encircling bracts, preferring to work in semi-darkness. And in the part of Queensland to which I refer certain species of *Formicidae* [ants] increase the surface otherwise available for operating on by building a loose wall of particles of vegetable debris from the base of the fruit some way upwards towards its apex Beneath this the mealy-bugs feed secure bestowing their sugary excretions upon the ants that in turn protect them from the attacks of their enemies. Thus it happens that the fruit may become much stunted in growth. This consortship with ants on the part of pine-apple mealy-bugs is a very marked occurrence in some parts of British New Guinea. Thus I have remarked in the island of Samarai the fruit whilst still but slightly developed is completely covered over by ants with a canopy composed of the above mentioned substance, and as a result of *Dactylopius* attack becomes brown and ultimately dry after having attained but quite small dimensions.'

A very similar condition of affairs is to be seen amongst the pine-apples at Antigua.

Ants also make galleries up the stems of plants, under cover of which they ascend, and in which scale insects may sometimes be found.

In all these cases the ants themselves do not appear to harm the plants. Any injury is, in all likelihood, due to the scale insects and the ants must be acquitted of direct damage. It must be noted however that, indirectly, harm may at times result from their fostering care of the really injurious creatures —the scale insects and mealy-bugs. Similarly when ants infest the roots of plants they are in the majority of cases to be found in association with scale insects. There is some reason to believe that, as mentioned above, ants may protect the scale insects from enemies, and may perhaps even carry the eggs or young insects to suitable places on the plant, and thus aid in distributing the scale insects. In cases, however, where ants have been prevented from visiting a plant infested with scale insects there is no evidence to hand showing a consequent diminution in the numbers of the scale insects, and no good results have as yet been obtained by destroying the ants in preference to the scale insects. On the other hand many cases of ants infesting plants are due solely to the presence of the scale insects or mealy-bugs. The damage done by the latter is attributed to the former but is easily remedied by destroying the scale insects or mealy-bugs, and leaving the ants unmolested.

HOW SOME PLANTS ATTRACT ANTS.

In the cases already considered it has been shown that the ants do not directly damage plants but often visit them on account of the inducements offered by the sweet excretions of certain insects which may be present.

The plant itself may also offer attractions to the ants, and their resulting presence has, in some instances, been proved to be of actual benefit to the plant which harbours them.

Many plants have what are known as extra-floral nectaries, which are nectar-excreting glands situated on other parts of the plant than the flowers. Common West Indian examples are those on the leaf stalks of the Siris tree or 'Barbados ebony' (*Albizzia Lebbek*), and the castor oil plant (*Ricinus communis*). In these two cases the nectaries are little raised bodies, with a crater-like depression at the top, usually moist with the excreted sugary solution. These nectaries are visited abundantly by ants which drink the sweet liquid. A plant which attracts a large number of ants to itself may find them of direct value, for they often appear to do good service in warding off caterpillars and other unwelcome visitors. It must not be supposed that it is necessarily a special, or as some might urge an 'intelligent' adaptation on the part of the plant to entice the ants to itself. The nectaries play their own part in the life-history of the plant, and the ants merely take an advantage of them, with sometimes beneficial results to the plant.

With two South American plants, the connection between plant and ants is much closer. The plants in question are the trumpet-tree, or '*bois-canon*' (*Cecropia*), and the 'bull's horn thorn' (*Acacia sphaerocephala.*) They live in regions infested by leaf-cutting ants, and without entering very fully into details it may be said that each maintains a standing army of ants which guards it from the ravages of the leaf-cutters. The first observations on these interesting cases were made by the well known naturalists Mr. Theodore Bent, author of *The Naturalist in Nicaragua*, and Herr Fritz Müller.

The ants live in the hollow spines (stipules) of the 'bull's horn thorn' and in the hollow joints of the stem of the trumpet-tree. A plentiful supply of food for the ants is to be found on the trees, the 'bull's horn thorn,' for example, having nectaries on the leaves which supply carbohydrates, and nitrogenous bodies on the tips of the leaflets. The garrison is thus in little danger of being starved out. Trees so occupied are not troubled by cattle browsing on them and are able to resist the attacks of the leaf-cutters. Observations have shown that their immunity is really due to the ants on them, for an individual tree without its standing army is readily stripped by the leaf-cutters. Plants such as these are botanically designated, 'ant-loving' (myrmecophilous) plants.

On the whole then, it would appear that the ants so commonly to be found on plants should not be looked upon, in the first instance at all events, as actual pests. They often indicate that a real pest such as green fly, scale insect, or mealy-bug is present. At times they may increase to

some degree the damage done by this pest. On the other hand, they may be visiting the plant on account of other inducements and their presence may even be of direct service in warding off the attacks of harmful creatures.

The treatment of really destructive ants such as the 'parasol' or 'umbrella' ant has already been described by Mr. J. H. Hart, in the *Bulletin* of the Trinidad Royal Botanic Gardens. The fumes of burning sulphur driven into the nests by a small machine called an Asphyxiator, or a small quantity of cotton wool soaked with bisulphide of carbon, appear to be convenient and effective remedies for these pests.

MISCELLANEOUS NOTES.

MR. JOHN BELLING, B.SC. (Lond.) formerly Science master at the Brecon County School, has been appointed, on the recommendation of the Commissioner of Agriculture for the West Indies, Science and Agricultural master at the Grammar School, St. Kitts. Mr. Belling's service dates from October 30, 1901.

MR. CHARLES H. KNOWLES, B.SC. (Lond.) formerly Science master at the County School, Brynmawr, Monmouthshire, has been appointed, on the recommendation of the Commissioner of Agriculture for the West Indies, Resident master of the Agricultural School, St. Vincent. Mr. Knowles embarked for the West Indies by the mail of January 8, 1902, and assumed the duties of his appointment on the twenty-first of that month.

Destruction of Mole Crickets. The mole cricket is a serious enemy of young plants, lawns and grassplots in several West Indian islands notably St. Vincent and St. Lucia, and is known to occur also in Dominica and Trinidad. The West Indian species (*Gryllotalpa didactyla*) differs little in structure from the European species (*G. vulgaris*), but its habits are apparently such that remedies found effective against the latter have proved unavailing in the West Indies. A new remedy has recently been described in a report of Mr. H. Maxwell-Lefroy, Entomologist to the Department, an extract from which was published in the *St. Lucia Gazette* for October 11, 1901. This method of treatment was brought forward by Mr. Powell, Curator of the St. Vincent Botanic Station, who learnt it from a planter in that island. It has been tested on infested lawns in St. Vincent and appears to be simple and very effective. The remedy consists in watering the ground with soapsuds, made by dissolving common hard soap in hot water, and then mixing with cold water at the rate of one

pound of soap to fifteen gallons of water. When this is liberally applied from a watering pot the mole crickets emerge from the ground and walk on the surface, when they may be readily collected and destroyed by burning or by being dropped into hot water. Other substances were tried, without avail, but dissolved soap appears to have a very speedy effect on the insects in the ground; the popular explanation is that 'the soap gets into their eyes;' though this is impossible from the structure of their eye, there is no doubt that it is an effective method. To water a tennis lawn about 100 lb. of soap would be needed, making the cost of the method about five dollars. In dry weather the solution should be weakened by adding more water, and equally when the soil is saturated with moisture the liquid should be more concentrated. The effect is only temporary, and once a lawn is freed from the insects, a watch should be kept to prevent mole crickets coming in from outside.

One way of doing this, found useful at St. Vincent, is to place around the lawn, or patches of grass cleared of mole crickets, thin strips of wood about fifteen to twenty feet long, four inches wide, set on edge and standing about three inches above the surface of the ground. The mole crickets, when travelling from place to place, do not attempt to climb over the wooden strips but run along the foot and are easily caught in small tin vessels containing water sunk into the ground to a depth of about ten inches. The vessels with water should be placed at the end of each strip or about ten feet apart, exactly in the track of the mole crickets, so that they may easily tumble into them.

Central American Rubber. It is generally considered that Central American rubber is the product of *Castilloa elastica* Cervantes, described and figured in the *West Indian Bulletin*, Vol. II, pp. 101-3. The tree has a variety of local names the most important of which are 'Hule' or 'Ulo' and 'Caucho.' Distinct from this plant is *Castilloa Tunu*, Hemsley (*Hooker's Icones Plantarum*, plate 2561), a tree also found in Central America and sometimes confused with the true Central American rubber tree which it closely resembles in general appearance. In an article which appeared in the *Beihefte zum Tropenpflanzer* for July 1901, Mr. Th. F. Koschny, a planter of long experience in Costa Rica, distinguishes the following varieties of 'Hule' trees:

Castilloa elastica:

'Hule blanco' ...	...	White rubber tree.
'Hule negro' ...	...	Black rubber tree.
'Hule colorado'	...	Red rubber tree.

Castilloa Tunu:

'Hule tunu' ...	...	'Gutta percha.'

The names of the three so-called varieties are given from the colour of the bark of the tree. 'Hule Blanco' is described as the only one worth cultivation, giving thick and abundant latex. The tree is not shade-loving, being seldom found in

forests, and not easily injured by tapping. 'Hule negro' gives a watery latex, and that of 'Hule colorado' whilst good, is scanty.

Mr. Koschny suggests that 'Hule colorado' may have been introduced into Java and Ceylon, and be the reason for the comparatively small returns given by Central American rubber trees in those islands. This point was touched upon by Dr. Morris in his Cantor Lectures on the 'Plants yielding Commercial India Rubber' to the Society of Arts in 1898 'The plants distributed from Kew and now under cultivation in various tropical Colonies would be more correctly termed, according to their place of origin, Darien "Castilloa" or Darien "Caucho" trees. This would distinguish them from the Ule trees of Mexico, British Honduras, and Nicaragua, and indicate their history. It is possible that there is no great difference, if any, in the quality of the rubber yielded by these trees, but so far no one has undertaken a comparative investigation of the produce.'

The Ceylon plant has been considered as possibly belonging to the species *Castilloa Markhamiana*, Markham, (Circular No. 11, Botanic Gardens Ceylon). On the other hand in the *Kew Bulletin*, for September 1901, Mr. W. B. Hemsley states that *Castilloa Markhamiana* is not distinguishable from *Castilloa elastica*.

Careful comparison at Kew between typical specimens of the rubber tree from British Honduras, Mexico, and Darien, so far, has failed to reveal any differences sufficient to warrant the recognition of definite varieties. Mr. Koschny's varieties have not yet been established botanically. Specimens have been sent by him to Prof. Warburg of Berlin, an authority on this group of plants, and their determination will be awaited with interest.

It is important meanwhile to draw attention to the fact that probably more than one variety may be cultivated under the name of 'Central American rubber tree,' and intending growers should be careful to secure seeds or plants from reliable sources.

ERRATUM IN THE PRESENT VOLUME.

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APPENDIX.

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